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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

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Birkenhead.
See Illustrated Advertisement Page 100, Jan. 28.

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See page 17, August 12. 9106

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Specification and Workmanship equal to Main Line Locomotives.
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See Advertisement page 95.

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See Advertisement page 26. 9091

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&c. &c. 9304

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(ELECTRIC).
9026
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See Advertisement page 69, August 12. 9402

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See half-page Advertisement page 81, August 5.

See Advt. page 31, Aug. 12
Steam & Pneumatic Power Hammers
Drop Stamping Plant
B. & S. Massey, Ltd., 9160
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The Manchester Steam Users' Association.

For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, Mount Street, Manchester.

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Prospectus from the Registrar, Merchant Venturers' Technical College, Bristol. R 766

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Complete Diploma Courses in Mechanical, Electrical, Mining and Oil Mining Engineering.

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Diploma Courses for Students preparing for the A.I.C. in Mineral and Organic Chemistry, Chemistry of Foods and Drugs, and Bio-Chemistry. Courses for Brewers' Chemists. Courses for Students preparing for the Pharmaceutical Examinations.

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A Two-Years' Course in Building Construction for Builders' Clerks and Surveyors has been instituted, leading to a Certificate.

Classes open 11th October.

Entrance Examination commences 27th September.

Prospectus and information on application to Principal at the College.

Peter Macnaughton, *Clerk.*

Heriot Trust Offices,
20, York Place,
Edinburgh,
August, 1921. R 776

University of Birmingham.

Faculty of Science.

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R. E. Stradling, B.Sc., A.M.I.C.E.
H. W. Coultas, B.Sc.
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and all Engineering Examinations.—Mr. G. F. Knowles, B.Sc., M.I.E., A.M.Inst.C.E., F.S.I., M.R.San.I., prepares candidates personally or by correspondence. Hundreds of successes. Courses may commence at any time.—36, Victoria St., Westminster, S.W. Tel. 4180 Victoria. 9340

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TENDERS.

North Eastern Railway.—To

Builders and Ironfounders.—The Directors are prepared to receive TENDERS for the ERECTION of ELECTRIC CAR SHEDS at South Gosforth, Newcastle-on-Tyne. Plans and Specification may be seen and Quantities and further particulars obtained upon application to Mr. Arthur Pollard, the Company's Architect, Irving House, Westgate Road, Newcastle-on-Tyne, on and after 22nd instant. Quantities supplied parties Tendering for the whole of the works. Sealed Tenders marked "Car Sheds, South Gosforth," to be sent to the Secretary at York not later than Nine a.m., 13th September. The Directors do not bind themselves to accept the lowest or any Tender.—W. H. D. Dewey, for the Secretary, York, 15th August, 1921. R 779

County Borough of Wallasey.

New Brighton Landing Stage Reconstruction.

The Corporation of Wallasey invite

Tenders for the Supply and

Delivery of 12 Cast Iron Compressors, with steel tie rods and plates, for the attachment of Landing Stage Moorings for the above, in accordance with the detailed Plans and Specification prepared by Messrs. Wilton & Bell, Consulting Civil Engineers, Westminster Chambers, 1, Crosshall Street, Liverpool. Plans and Specification may be seen at Messrs. Wilton & Bell's Offices by appointment, and Contractors desiring to obtain copies of the Plans may do so on payment of £1 1s. Tenders on the Form of Tender provided must be delivered to the undersigned, in a Sealed Envelope, endorsed "Tender for New Brighton Landing Stage Compressors," not later than Noon, Saturday, September 17th, 1921.

Geo. Livsey,
Town Clerk.

Town Hall, Wallasey,
2nd August, 1921. R 647

The Burma Railways Company, Limited.

The Board of Directors of the Burma Railways Company, Limited, are prepared to receive

Tenders for the Supply of:—

100 Tons Mild Steel Channels and 140 Mild Steel Plates.

For each copy of the specification a fee of 20/- will be charged, which fee is not returnable. Tenders enclosed in sealed envelopes addressed to the "Chairman and Directors" and endorsed "Tender for Steel Material" must be delivered at the Company's Offices not later than Twelve Noon on Friday, 26th August, 1921. The Directors do not bind themselves to accept any or the lowest tender and reserve the right to divide the order.

The material is very urgently required in Burma.

By Order of the Board,
W. Homb,
Managing Director.

199, Graham House,
Old Broad Street,
London, E.C. 2.
17th August, 1921. R 793

Ventnor Urban District Council.

Repairs to Tie Rods, &c., to the Royal Victoria Pier and Landing Stage.

The Ventnor Urban District Council invite

Tenders for the Repair and

Replacement of a number of Tie-Rods and other Ironwork to the understructure of the Royal Victoria Pier and Landing Stage, Ventnor Pians, Sections and Specification may be seen, and full details obtained, at the offices of Mr. D. V. Howard, the Engineer and Surveyor to the Council, Town Hall, Ventnor, I.W.

Tenders, sealed and endorsed, "Pier Repairs," to be delivered to the undersigned, Clerk to the Council, not later than Noon on the 7th day of September, 1921.

The Council do not bind themselves to accept the lowest or any Tender.

(Signed),
R. Hughes Oakes,
Clerk to the Council.

Town Hall, Ventnor, I.W.
30th July, 1921. R 636

The South Indian Railway Company, Limited, are prepared to receive

Tenders for the Supply of:—

(1) Steel Axles.
(2) Steel Boiler Tubes.
(3) Steel Tyres.

Specifications and Forms of Tender may be obtained at the Company's Offices, 91, Petty France, Westminster, S.W. 1.

Tenders addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked "Tenders for Steel Axles," or as the case may be, must be left with the undersigned not later than Two p.m. on Wednesday, the 7th September, 1921.

A charge, which will not be returned, will be made of 20s. for each copy of the Specifications.

Copies of the Drawings may be obtained at the Office of Messrs. R. Wynn & Partners, Consulting Engineers to the Company, 3, Victoria Street, Westminster, S.W. 1.

A. Muirhead,
Managing Director.

91, Petty France, S.W. 1.
15th August, 1921. R 806

Metropolitan Water Board.

Tenders for the Supply and Erection of Pumping Machinery at Littleton, Middlesex.

The Metropolitan Water Board invite

Tenders for the Supply and

Erection of Pumping Machinery, at Littleton, Middlesex, having a maximum capacity of 360 million gallons per 24 hours against a head of 46 feet.

Forms of Tender, Conditions of Contract, Specification and Drawing may be inspected without payment of fee at the Offices of the Board (Room 173) Chief Engineer's Department, Rosebery Avenue, Clerkenwell, E.C. 1, on and after Friday, 26th August, 1921.

Contractors desirous of tendering may obtain the necessary documents from Mr. Henry B. Stilgoe, M.Inst.C.E., the Chief Engineer, on production of an official receipt for the sum of £3 3s., which sum must be deposited with the Board's Accountant and will be returned on receipt of a *bona fide* Tender together with all incidental papers.

Such payments and applications must be made between the hours of Ten a.m. and Four p.m. (Thursdays and Saturdays excepted).

Tenders enclosed in sealed envelopes, addressed to "The Clerk of the Board, Metropolitan Water Board, 173, Rosebery Avenue, E.C. 1," and endorsed "Tender for Machinery, Littleton," must be delivered at the Offices of the Board not later than Ten a.m. on Wednesday, 16th November, 1921.

The Board do not bind themselves to accept the lowest or any Tender.

W. Moon,
Clerk of the Board.

Offices of the Board,
173, Rosebery Avenue, E.C. 1.
15th August, 1921. R 797

County Borough of Wallasey.

Seacombe Ferry Improvements.

The Corporation of Wallasey invite

Tenders for the carrying out

of that portion of the above work denominated Work "A," which comprises a New Floating Goods Landing Stage, approximately 220 ft. in length and 80 ft. in breadth, and Works in connection therewith, in accordance with the detailed Plans and Specification of Messrs. Wilton & Bell, Consulting Civil Engineers, Westminster Chambers, 1, Crosshall Street, Liverpool, the Engineers for the work, at whose offices copies of the Plans and Specification may be seen. Contractors desiring to obtain copies of Plans and Specification may do so on payment of £5 5s. Tenders on the Form of Tender provided must be delivered to the undersigned, in a Sealed Envelope, endorsed "Tender for Seacombe Ferry Improvements, Work 'A,'" not later than 12 noon Saturday, October 15th, 1921.

Geo. Livsey,
Town Clerk.

Town Hall, Wallasey,
2nd August, 1921. R 646

To Electricians and Others.

The Metropolitan Asylums Board invite

Tenders for Carrying Out the

Installation of Electric Lighting in the Administrative Block, Ward Blocks Nos. 1 and 2, Covered Ways, Road Lighting, etc., at the Grove Hospital, Tooting Grove, London, S.W., in accordance with Drawings and Specification prepared by Mr. T. Cooper, M.Inst.C.E., M.I.Mech.E., Engineer-in-chief.

The Drawings, Specification and Forms of Tender may be inspected at the Office of the Board, Embankment, E.C. 4, on and after Ten a.m. on 18th August, and the drawings, specification and forms of tender can then be obtained upon payment of a deposit of £1.

The amount of the deposit will be returned only after the receipt of a *bona fide* Tender sent in accordance with the instructions of the Form of Tender and after the specification and other drawings have been returned.

Tenders, addressed as noted on the form, must be delivered at the Office of the Board, not later than 2.30 p.m., on 31st August.

By Order,
Duncombe Mann,
Clerk to the Board. R 775

Burgh of Macduff.

Macduff Harbour Slipway.

The Macduff Town Council are prepared to receive

Tenders for the Construction

and Erection at Macduff of a Steel Cradle, two Traversers, and Machinery for the above Slipway.

Copies of the Specification, Conditions, Schedule, Form of Tender, and the Drawings may be inspected at the Office of the Subscriber.

Contractors desirous of Tendering may obtain the necessary documents on payment of the sum of Two Guineas which will be returned on receipt of a *bona fide* Tender together with the documents.

Tenders are to be lodged with the Subscriber on or before Saturday, the 3rd September, 1921.

The Town Council do not bind themselves to accept the lowest or any Tender.

Arch. Henderson, M.Inst.C.E.,
21, Bridge Street,
Aberdeen. R 769

Bombay, Baroda and Central India Railway Company.

The Directors are prepared to receive up to Noon on Friday, 9th September,

Tenders for the Supply of—

Class A.
1. Rolled Material for the construction of Wagons.
2. Wheels and Axles for Wagons.

Class B.
1. Helical Springs.
2. Spring Steel.
3. Accumulator Supplies.

Tenders must be made on forms, copies of which, with Specification, can be obtained at these offices on payment as follows:—

For Class A, 20s. each and for Class B, 10s. each. (which will not be returned).

The Directors do not bind themselves to accept the lowest or any Tender.

S. G. S. Young,
Secretary.

Offices:
The White Mansion,
91, Petty France,
Westminster, S.W. 1.
17th August, 1921. R 817

G. R.

By Direction of the Disposal Board.

The following Miscellaneous

Plant & Machinery to be Disposed of as a Whole by Public Tender.

Location:—C.S.D. 86, Hereford.

Wheels and Axles. 14 Rotary Converters. Universal Accessory Box. Pack Set. Three D/C Motors, Crompton 25 B.HP. 440/460 V. Spare Armature for 25 B.HP. Crompton Motor. Fruit Slicing and Shredding Machine. Two Auto Steam Heated Cooking Machines. Rotary Potato Washing Machine. Large Potato Peeling Machine. Two Fruit and Vegetable Washing Machines, New Rocker Type. Cross-cut Saw Bench. Hyd. Spring Testing Machine. Two Heavy Duty Vertical Drilling Machines, 37 in. Asquith. Four Overhead Travelling Cranes, with pulley blocks and chains. Lumsden Triple end Grinder and Accessories. Lumsden Oscillating Grinder and Accessories. 8 A.H.P. Siemens Motor, 3 phase A.C.

Closing Date of Tenders—Aug. 31st.

Further applications and permits for inspection may be obtained from the Controller, Plant and Machinery Section, Room 53, Block "G," Earl's Court Exhibition, S.W. 5. R 763

APPOINTMENTS OPEN.

University of London, University College.

Applications are Invited for

the position of Senior Assistant in the Department of Civil and Mechanical Engineering, which is under the direction of Professor E. G. Coker. The work requires training and experience in Engineering Design and Drawing Office practice.

Salary £450 to £500 (pensionable) according to qualifications and experience. Further particulars may be obtained from:

Walter W. Seton, M.A., D.Litt.,
Secretary,
University College, London,
Gower Street, W.C. 1. R 639

The University of Manchester.

Department of Engineering.

The Council is about to proceed to the

Appointment of an Assistant

Lecturer in Engineering and Instructor in Drawing, who would be expected to enter on his duties on 29th September, 1921.

Salary £300 per annum. Further particulars may be obtained from the Internal Registrar. Applications, giving 3 references, should be sent to the Internal Registrar not later than 29th August. Testimonials (one copy of each, which need not be printed) may be submitted. R 707

The University of Liverpool.

Lecturership in Metallurgy.

The Council invite

Applications for the Post of

ungraded Lecturer in Metallurgy for Session 1921-1922 at a salary of £300, duties to commence on 1st October, 1921. Applications and three copies of testimonials should be forwarded to the Registrar on or before 26th August.

Edward Carey,
Registrar.

3rd August, 1921. R 681

Doncaster Education Committee.

Teacher of Electrical Engi-

neering and Mathematics (Full-time) WANTED for the Technical College. Full particulars may be obtained from J. Eagles, A.R.C.Sc., Principal, Technical College, St. George Gate, Doncaster.

G. R. H. Danby, M.A.,
Secretary.

Education Offices,
Doncaster.
August 17th, 1921. R 809

Leigh Municipal Technical School.

The Committee require the

Services of a Teacher of Mine

working and mining law; one evening each week. Applications should be sent to the undersigned as early as possible.

James Ward,
Director of Education.

Education Offices,
Town Hall, Leigh,
August 16th, 1921. R 796

Doncaster Education Committee.

Junior Technical School.

Metal Work Teacher Wanted at once. Full particulars may be obtained from J. Eagles, A.R.C.Sc., Principal, Technical College, St. George Gate, Doncaster.

G. R. H. Danby,
Secretary.

Education Offices,
Doncaster. R 693

Croydon Education Committee.

Central Polytechnic.

Wanted, for September,

Teachers for the following classes:—
Electrical Engineering—Alternating Currents (Friday).
Wireless Telegraphy (Tuesday).
Mechanical Engineering, Hlem. (Tuesday).

Further particulars may be obtained from the Principal, Central Polytechnic, Scarbrook Road, Croydon.

J. Smyth,
Clerk to the Committee. R 788

Shanghai Municipal Council.

Assistant Civil Engineer.

The Electricity Department of the Council requires the

Services of a Civil Engi-

neering Assistant for constructional work in connection with the power houses, substations, etc.

Candidates should have had thorough technical education and practical experience, particularly in building construction, reinforced concrete work and structural steel work. The engineer appointed will be required to make all calculations and to supervise the preparation of detail drawings, and generally to assist the Civil Engineer.

Preference will be given to candidates who have passed the examination for Associate Members of the Institution of Civil Engineers or equivalent examination.

Salary, 400 taels per month. First engagement three years.

Free passages and free medical attendance. The usual rate of exchange is about 3/0d. per tael.

Applications, stating age and full particulars of training and experience, together with copies of recent testimonials and names of references as to personal character, to be sent to PREECE, CARDEW & RIDER, 8, Queen Anne's Gate, Westminster, S.W. 1, not later than Tuesday, 30th August. R 785

Wanted for Indian Galvan-

izing Works, an Engineer (unmarried) as Assistant Manager, with practical experience in the manufacture of Galvanized Tanks, Buckets, Hollow-ware and Light and Heavy Galvanized work generally.—Write, stating age, experience and salary required to Z.Y. 347, care of Deacons, Leadenhall Street, London. R 801

THE 72-IN. REFLECTING TELESCOPE FOR THE DOMINION OF CANADA.

(*Concluded from page* 244.)

WE have now to deal with the optical features of the instrument we are describing. The main mirror is a glass speculum of 73 in. outside diameter and 12 in. thick at the edge, weighing 4,340 lb. Through the centre of this mirror a hole was cast and bored out to 10½ in. diameter. The mirror is ground, polished and exactly figured to a surface which is a true parabola of revolution having a focal length of 30 ft.

The Newtonian flat is a plane mirror about 19 in. diameter and 3 in. thick, silvered on its front face and inclined at an angle of 45 deg. to the axis of the main mirror. It is placed in the upper end of the tube, about 48 in. from the prime focus of the main mirror. Its function is to reflect the image to the side of the tube and to allow of observing visually and photographically at the side of the tube, generally called observing at the Newtonian focus.

The Cassegrain mirror has as a surface a hyperbola of revolution, and is 19½ in. in diameter, and 3 in. thick; it is placed about 7 ft. from the prime focus, reflecting the light back down the tube through the central hole in the main mirror, and bringing the rays to a focus about 3 ft. beyond that mirror. This gives an equivalent focus of 108 ft.

The spectrograph, which we shall describe later, is attached so that the slit is in the focal plane of the Cassegrain combination. A draw tube with right angle prism can be slipped into place just in front of this slit (see Fig. 32 on page 270), so as to allow visual observations to be made at the Cassegrain focus without disturbing the spectroscope.

The telescope is equipped with three finders, two being of 4 in. aperture and 60 in. focal length, while a long focus finder of 7 in. aperture and 30 ft. focal length is provided for guiding. For visual observation, a series of oculars are provided giving different magnifications for use in both the prime focus and the Cassegrain focus.

A double slide plate-holder permits photographs to be taken in the prime focus position, or at the side of the tube in the Newtonian focus. The plate-holder is of steel construction with abutting and aligning lugs, so that it can be removed and accurately replaced. The plate-holder carrier, or mechanism, consists of three slides. To the upper one is fastened the plate-holder itself and two guiding eyepieces. These have electrically-illuminated cross-wires, and can slide in two directions, at right angles, so as to set upon any two bright stars in the field of view. The screws moving these wires are operated from the edge of the tube (see Fig. 13, page 241 *ante*), when the holder is being used at the prime focus, or by a pair of knobs when used at the side of the tube. This upper plate, with the guiding eyepieces, can be rotated a small amount by means of a screw so as to give the correction of the field rendered necessary by the variation of refraction with altitude. The two lower slides which carry the upper slide can be moved at right angles to provide a small movement in two co-ordinates to correct for any slight displacement of the star image, due to temperature changes, atmospheric disturbances, or other causes. The guiding rods provided for use when working at the prime focus are supported at the outside edge of the tube by a sliding carriage which fits on the bevelled plate at the upper end of the tube, and also carries the guiding eyepieces as well as the observing telescope, which can be used to observe visually when the plate holder is removed. The whole arrangement is shown in Fig. 13 just referred to.

The operation of the plate-holder is quite simple in spite of the many adjustments. The plate-holder carrier is focussed by observing the star image on a knife edge, placed in its cell exactly in the same plane as the photographic plate. When accurately focussed the knife edge is removed and the plate-holder substituted. The observer then opens the folding shutter directly beneath the plate, and observes any conveniently-located star through one of the guiding eyepieces and guides on it by using the control handles which move the two lower slides. At intervals he looks through the other guiding eyepiece to detect and correct any traces of rotation of field. Exposures will vary from a few seconds to many hours, depending upon the object which is being dealt with.

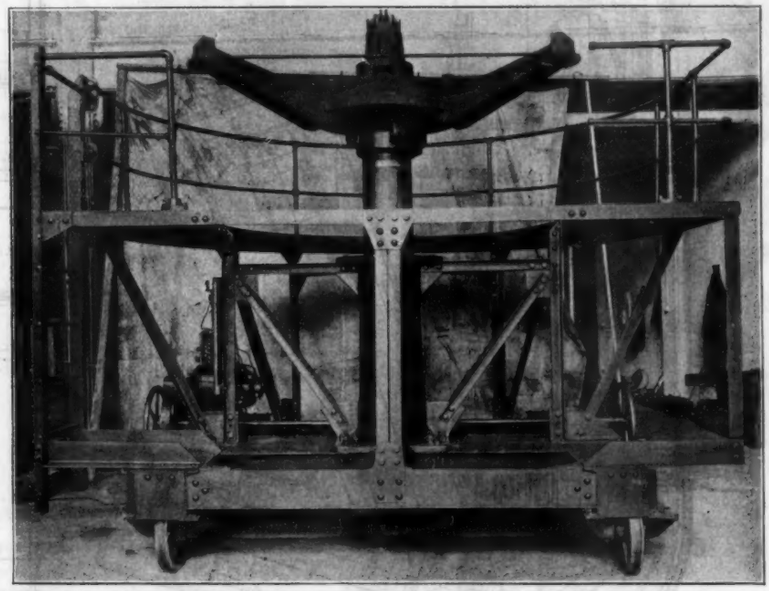


FIG. 30. THE SILVERING CAR.

The main mirror will, of course, require resilvering from time to time, and as the handling of so delicate and at the same time so massive a piece of glass as the 72-in. mirror is a very hazardous undertaking, a special method of performing the operation was worked out. The telescope is first set so that the tube is vertical on the east side of the polar axis and securely stayed. The silvering car, which is illustrated in Fig. 30, annexed, consists of a heavy truck, running on tracks on the floor of the observatory, the tracks being so laid that the centre of the car can be brought directly under the centre of the telescope tube. Mounted on the car is a hollow cylindrical casting which is provided with flanges at the top and bottom and is strongly braced by angle irons at the top as shown. This cylinder is about 3 ft. high and is bored out to 12 in. diameter. It is fitted with a plunger which can be moved vertically through a range of about 2 ft. by a screw actuated by an electric motor or by hand. The plunger is conical at its upper end and in its top face a hemispherical cavity is formed in which is placed a hardened steel ball, 2 in. in diameter. Resting on this ball is a cradle or rocker, built up of steel castings and having three arms about 4 ft. long on the ends of which are projections which fit on the outer edge of the mirror cell. The cradle is so designed that centre of gravity of the combined cradle, mirror and mirror cell is situated practically at the centre of the ball on which the cradle rests, and it is thus possible with comparatively little effort to rock the mirror during the process of silvering. When the cradle has been brought into the proper position under the telescope tube it is raised by means of the plunger and screw until the arms take a firm bearing on the mirror cell.

The mirror with its cell weighs about 6 tons, and before detaching this weight from the telescope tube it is necessary, as we have already stated, to fix the latter so that no movement shall be caused by its being thrown out of balance. Two possible movements have to be guarded against, namely, a rotation of the polar axis and a rotation of the declination axis. The first of these is prevented by supporting the outer end of the declination axis on a steel stanchion which is counterbalanced and moves vertically in an encasing stanchion which extends from the steel observing floor to the ground floor of the building. A trap door in the floor enables this telescopic stancheon to be run up until a conical point at its upper end enters a corresponding socket in the declination housing. A short piece of I-beam resting on the floor is then pushed through an opening in the stanchion, making things secure.

As regards the second possible movement it has to be borne in mind that the telescope being vertical is balanced, although in unstable equilibrium, and it can readily be retained in its position by lashing the upper end of the tube to rings provided in the main ribs of the dome for that purpose.

The telescope being secured, the bolts securing the mirror cell can be removed, leaving the cell resting on the cradle, and the latter can then be lowered and the cradle can be moved to the east on its track until clear of the telescope tube. A band of paraffined paper about 8 in. high secured around the periphery of the mirror and a plug placed in the central hole convert the mirror into a dish for holding the chemical solutions, while the manner in which the cradle is mounted enables the mirror to be given the rocking movement necessary to enable the solutions to be moved uniformly and regularly over the surface. By removing the central plug the solutions can be conveniently drained away.

We must now deal with the spectrograph, which forms such an important accessory to the instrument we are describing. A spectrograph consists primarily of a slit in the focus of a collimator objective providing parallel light, a prism or other mediums, whose purpose it is to disperse the light into a spectrum, and a photographic camera to photograph the spectrum. In order to increase the dispersion more than one prism is often employed. In the case of the spectrograph for the 72-in. telescope three prisms are provided for and three photographic cameras of different powers are used, so that one, two or all three prisms may be employed.

The earlier spectrographs were all of a universal type that is, they were to be used with different dispersions, and different spectral regions were observed. But when the field of stellar spectroscopy narrowed to the measurement and determination of radial velocities, the universal type became obsolete, because of several inherent difficulties arising in this type. The rigid fixed form was then developed. This, however, had disadvantages due to the supporting members and spectrograph being in one unit; this resulted in flexures, caused by the weight of the spectrograph, which introduced noticeable errors in the observations. To overcome this the later spectrographs were designed so that the spectrograph proper was in a suitably constructed box, supported flexibly at

two chosen points by the truss which attached it to the telescope.

In the spectrograph for the 72-in. telescope an attempt was made to combine the advantages of the two-point box construction with the flexibility and general usefulness of a universal instrument. It was decided to revert to the older or universal type as no one, two, or three fixed type spectroscopes could meet the various demands certain to be made upon them by so large and powerful an instrument as the 72-in. reflector.

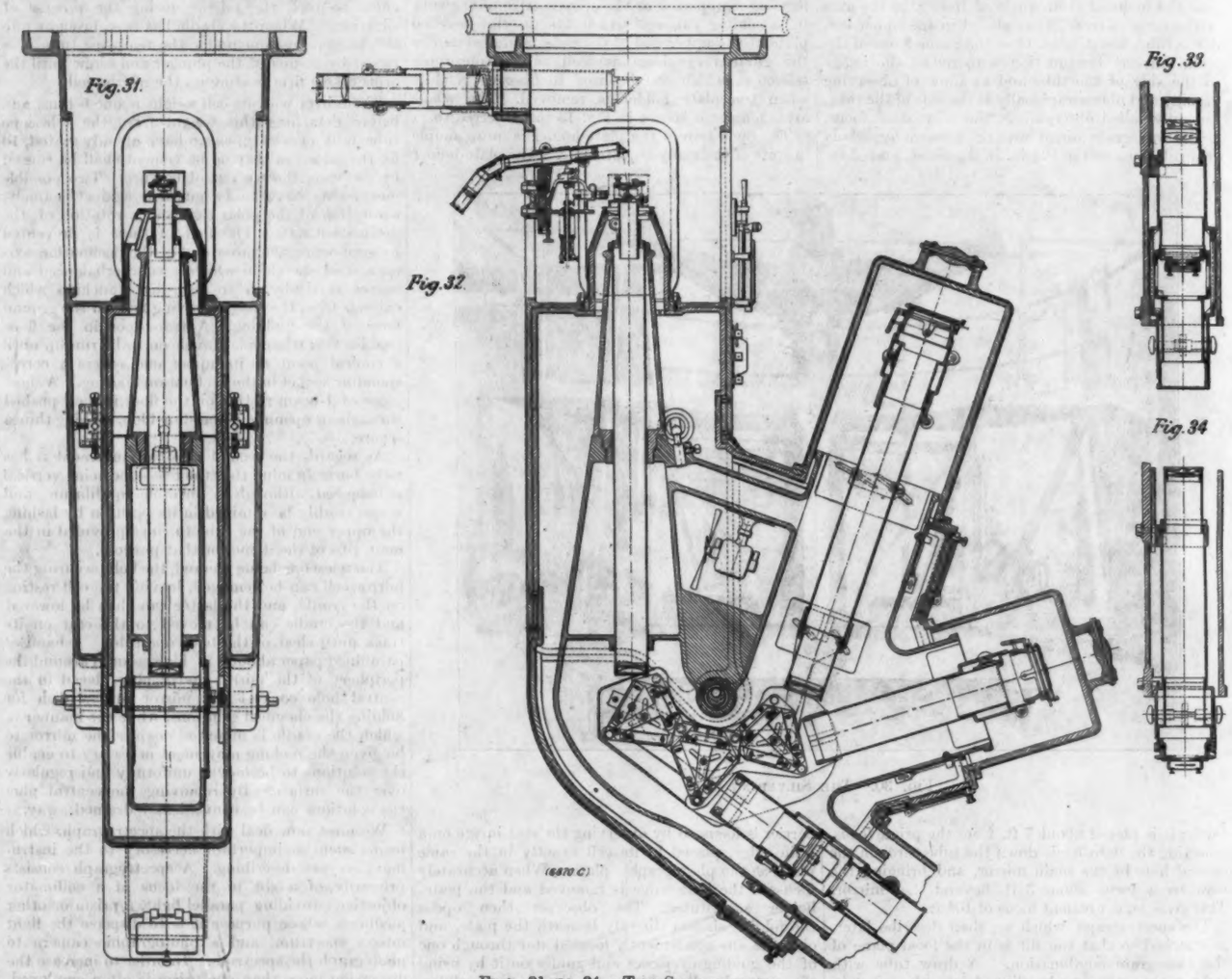
Sectional views showing the construction of the spectrograph are given in Figs. 31 to 34, subjoined, while Fig. 35, on page 271, is a reproduction of a photograph showing the spectrograph attached to the telescope. The frame which supports the spectrograph box is a long box-shaped, special aluminium alloy casting. At one end is a large flange by which it is bolted to the spectrograph ring at the bottom of the mirror cell, as shown in Fig. 35. This ring is fastened to a large cast-iron worm wheel, bearing on a heavy shell fastened to the bottom of the mirror cell. By means of a worm, operated by a hand wheel conveniently located near the spectrograph, the spectrograph can be rotated in azimuth. The lower end of the frame carries two heavy lugs through which passes the pin for swivelling the spectrograph box. This pin has eccentric ends where it passes through the frame, and at its centre a ball seat. This construction allows the spectrograph box to swivel freely in any direction. About midway between the supporting lugs and the large flange at the other end of the frame is a ball-headed aligning pin which engages a slotted bar in the spectrograph box, keeping it in alignment. By means of this pin and the eccentric supporting shaft the spectrograph can be accurately aligned to the main telescope. Near the upper end of the frame are four large openings, giving free access to the slit mechanism and the guiding eyepieces and comparison mechanism. These details are clearly shown in Fig. 32.

The spectrograph box is, as we have stated, an aluminium casting, and has four projecting hollow arms. One of these carries the collimator and slit and projects up into the hollow attaching frame. It is attached to the longer of the three remaining arms by a hollow box girder which is integral with the box casting. The projecting hollow arms carry the three spectrograph cameras. Directly over the prisms and their supporting mechanism is a semicircular opening, allowing free access to the prisms and the link movement. Since this box is one casting with an opening on one side only, it is very rigid, and being made of aluminium it is very light.

A link-work is provided for carrying the prism cells always at a minimum deviation, whatever part of the spectrum is central. This is made up of bronze links with gear teeth at the ends and pivoted so as to have a multiplying action for each prism added. The prism tables are attached to the upper of the two series of links, and the upper and lower series together give the desired amplification of prism movement.

A scale and magnifying index makes possible the setting to any region or recovering it when desired. Attached to each prism table is a long arm with a slotted end into which the camera fits so as to line up camera and prism set in the proper relation. The prisms themselves are not held by the link work alone, but can be clamped, by bolts passing through each corner of the prism table and two at each end of the cameras, to the heavy bottom of the spectrograph box. The prisms have an aperture of 2·5 in. The prisms are mounted in substantial prism cells, which are held in place on the movable prism tables by screws and dowel pins so that any prism can be removed and accurately replaced. This is of advantage, as it saves readjustment when changing from one type of spectrograph to another. With this arrangement it is possible to change from one type of spectrograph to another in less time than it would be possible to change spectrographs.

The collimator objective is 63·5 mm. aperture and 1,143 mm. focal length, triplet type. This construction makes change of focus with change of temperature compensatory, and does away with the adjustment of camera focus for summer and winter observing. The collimator is clamped in the most convenient position and the star image focussed on the slit jaws by moving the secondary mirror by the hand wheel at the guiding eyepiece. This is a very accurate and convenient method, for the image is readily examined visually. The cameras are of box construction with the objectives fixed in position. The apertures of the camera objectives are 76·2 mm. and their focal lengths are 380 mm., 711 mm. and 965 mm.; all are of the triplet type. The focusing is accomplished by moving the plate holders in and out by a rack and pinion. The focusing adjustment can be read by a scale and vernier to tenths of a millimetre. The metal plate holders, opening in the middle, hold a plate 2 in. by 4 in., which is held down against



Figs. 31 to 34. The Spectrograph.

a raised surface around the opening by a spring. The free aperture of the plate holder is 1 in. by 3·5 in. The plate is thus supported parallel to the spectrum through its entire length, and curvature will have a negligible effect on spectrum measurements. The plate holder can be tilted about 15 deg. each way and the amount of this movement can be read on a graduated arc so that it is possible to adjust the plate tangent to the focal plane. The cameras are operated through doors in the temperature case for the medium and long focus cameras, but as the plate in the short focus camera comes within the spectrograph box, suitable doors with hinged covers in both spectrograph box and temperature case are provided.

The temperature case—which can be seen on the floor in Fig. 35—is attached to the supporting frame and does not touch the spectrograph box at any point. It is made of a cast aluminium frame with sheet aluminium sides, and is firmly attached to the supporting frame. At the ends over the camera projections are covers and also large circular openings at each side, which enable all changes and adjustments to be made without removing the case. The case and all openings and covers are lined with ½-in. felt; the supporting frame is also lined inside where the collimator tube projects into it, making the entire spectrograph box and collimator completely enclosed in a felt temperature case.

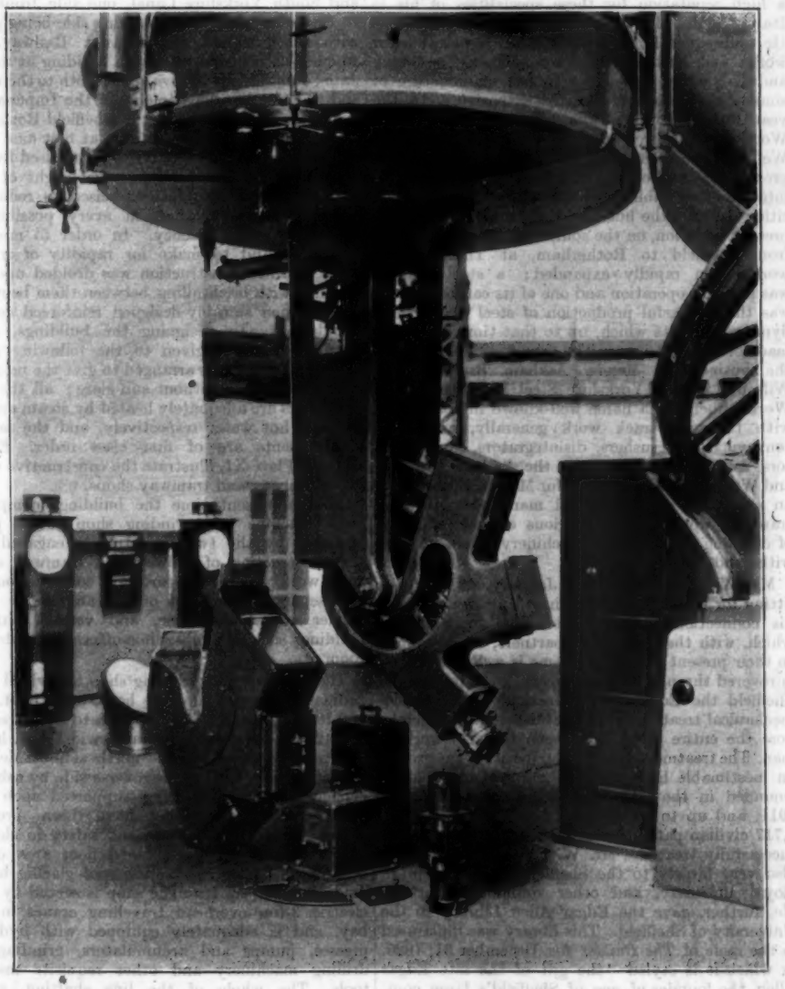


Fig. 35. The Spectroscope with Temperature Case and Covers Removed.

Uniformly distributed over the inside of the case, and attached to the felt are insulated German silver wires, through which 110-volt lighting current is passed. A fan keeps the air inside the case in constant circulation. As the difference in temperature between inside and outside of case is rarely more than 3 deg. to 4 deg. C. very little current is required. The heating current is regulated automatically by a mercury contact thermometer operating a relay, which keeps the difference of temperature well within 0·1 deg. C.

The slit jaws are of polished nickel inclined at an angle of 3·5 deg. to the normal to the optical axis in order to obtain a reflected image from the upper surface of the jaws into the guiding eyepiece (see Fig. 32). One of the jaws is fixed and the other is moved by a micrometer screw reading to thousandths of an inch. Guiding is done by observing the reflected image through a right-angled prism and broken guiding telescope. The 45-deg. bend in the guiding telescope allows the guiding eyepiece to be rotated to the most convenient position.

The comparison spectra are obtained by reflecting the light of an iron arc through the slit jaw to form spectra on either side of the star spectrum. This is accomplished in a new way by reflecting the comparison light down through two right angle prisms which lie just above the slit and have their edges parallel to it. These prisms can be brought into contact or separated symmetrically along the direction of the slit by a right and left-hand screw. This is done to vary the distance apart of the comparison spectra and the star spectrum. The prisms can also be moved transversely to the slit, toward or from the comparison source by a rack and pinion. They are held in their seats by thin metal plates lying just above the slit, which are cut out to serve as limiting diaphragms for star and comparison light. The star's light passes through the wedge-shaped opening in these plates and the comparison light through the rectangular opening. As these plates move with the prisms, any width of spectrum can be obtained depending upon the position of the wedge-shaped opening, while wider spectra limited only by the length of the slit can be obtained by separating the prisms. Three adjustable stop screws for the movement of the prisms allow the usual widths to be reproduced at will. There is further a central opening in these plates to allow a central strip of comparison spectrum to be placed between the outer strips, which, in conjunction with a semicircular diaphragm inserted at the collimator objective, permits the use of the Hartmann method for focusing the camera.

The comparison spectra can be applied as often as desirable, without stopping or affecting the exposure on the star spectrum or touching the slit head; this is done by merely turning on the 220-volt direct current iron arc. The comparison arc and guiding telescope are adjustably attached to the supporting frame and do not touch the spectrograph box or slit head, and no pressure on them can possibly affect the positions of the lines. This slit head and comparison arrangement always remains in adjustment, gives uniformly exposed spectra, and has the additional advantage, as we have just mentioned, of allowing for focusing of the camera by the Hartmann method.

Just above the slit head, provision has been made for attaching a visual telescope. This has a right angle prism at the end and brings the light out at right angles to the optical axis of the telescope, and allows the star and nebular images to be observed visually without necessitating any change in adjustment of the spectrograph. This is a great convenience, as it allows the instrument to be used visually for public demonstrations without interfering in any way with any adjustments made for research work in the observatory.

To remove the spectrograph it is necessary first to set the tube vertical and adjust the stays. The spectrograph is then clamped to an arm projecting from the cradle of the silvering car, and the arm drawn tight by means of a tension rod and turnbuckle. The spectrograph retaining bolts are removed, and the cradle and spectrograph lowered from the tube; the silvering car and spectrograph can then be rolled out of the way.

The observatory has now been in use for nearly two years and ample time has passed for the observers to become thoroughly acquainted with all the details of the building, dome and instrument. Naught but words of praise and commendation have come from all connected with the observatory and we think it only right to quote the following signed statement, made by Dr. J. S. Plaskett, the director, as it is clearly indicative of his opinion of this monument of American engineering skill and scientific achievement. He says: "It gives me pleasure to have this opportunity of stating my opinion of the 72-in. telescope. Before discussing the mounting, however, the quality of the optical parts, made by the John A. Brashear Company, of Pittsburgh, should be referred to. The principle mirror of 72-in. aperture and 30-ft. focus is of exceptionally fine figure, nowhere departing from the theoretical form to a greater extent then one-eighth of a wavelength of light, about one four hundred-thousandth of an inch. As a consequence it gives exquisite definition, resulting in very small stellar images, a minimum diameter of about 1 second of arc, when used in direct photography; and when the Cassegrain combination is used with the spectrograph the exposures required are relatively short, indicating equally good correction of the convex mirror. The optical parts as well as the mounting are of the very highest quality.

"The mounting excels any previously constructed in the completeness and beauty of its design, in strength and simplicity of mechanism, in ease and convenience of operation and in accuracy and smoothness of running. The photographs show the well-proportioned external form of the instrument, while the description and drawings show how few parts there are requiring oiling or attention. The convenience and accuracy of operation will be

evident when it is stated that the average time required, when using the spectrograph, to change from star to star, from the end of the exposure on the spectrum of one star to the beginning of that on the next is about 3 minutes, and if the stars are not far apart in the sky, is only 2 minutes. The driving is extremely smooth and accurate, as even with the 108-ft. focus and a power of 1,500 the image remains stationary and there is no indication whatever of the annoying and troublesome periodic driving error so frequently present in equatorial telescopes. The slow motions also work very smoothly and uniformly without backlash or irregular motion. In brief, eighteen months use of the telescope has failed to show me a single particular in which improvement could be effected, and for its purposes the whole instrument is so practically perfect that its operation is a constant pleasure."

THE WORKS OF MESSRS. EDGAR ALLEN AND CO., LIMITED, SHEFFIELD.

That the late war, almost from the very day it was started by Germany, was an engineers' war has long been generally recognised. There is, however, some danger that, as time passes, the great part played by engineers who were not normally concerned in armament construction may be forgotten. Our great private arsenals proved, as was anticipated, a reserve of the utmost value to our defences; they did, indeed, yeoman service and deserve all gratitude for the very important lead they took in assuring victory. But quite apart from them, or rather, we should say, working hand-in-hand with them, there were numerous other firms previously employed on work of a non-military character, but who, immediately hostilities commenced, readily severing long and remarkably well-established trading connections, gave up the manufacture of the specialities on which their reputation was founded and placed their resources unreservedly at the disposal of the military authorities. Furthermore, they extended and modified their plant and transformed in very many instances their methods of working with a view better to meet the special requirements of the situation. These important changes had frequently to be carried through under great difficulties, owing to the staff being depleted of skilled craftsmen and also, owing to extraordinary delays in the delivery of raw materials.

A typical example is afforded by the war time record of Messrs. Edgar Allen and Co., Limited, the Imperial Steel Works, Sheffield, the well-known makers of manganese steel, tool steel and special alloy steels, files, circular saws, twist drills, steel castings, railway and tramway special track work, crushing and grinding machinery, cement and powdered fuel plant, mining stamp shoes and dies, &c. The great experience they had acquired during many years past in steel metallurgy and in a number of branches of engineering led to their being singled out as valuable contributors to the nation's defence, and shortly after hostilities broke out their books were full of war orders. Generally speaking, these orders were for increased quantities of the firm's standard products rather than for entirely new ones, but certain new lines, as, for instance, bullet resisting helmets, were undertaken. The change-over from peace to war work was, therefore, more in the nature of extensions than alterations to existing plant, and to meet the ever-increasing demands of the nation, frequent expansions of the works became necessary, the total increase in area since 1914 being 14 acres, bringing the total acreage up to 35. During the war period, they supplied over 40,000 tons of castings to other munitions factories, including paravane detail parts, hydraulic shell-press cylinders, submarine electric motor and bedplate castings, motor lorry wheels, parts of trench locomotives, "tank" chain links and gear, &c. They also manufactured bullet-resisting armour plates for "tanks," high-speed-steel cutting tools, over a million special pressed steel bullet-proof helmets, cast steel aeroplane bombs varying in weight from 1 cwt. to 5 cwt., and kept over a dozen national shell factories regularly supplied with various descriptions of tool steel. The directors served upon committees and associations formed for the purpose of unifying the nation's output of war material; technical members of their Railway Track department were lent to assist railway construction in France, and their steel foundry manager went to the aid of the Ministry of Munitions. Another very important point which serves further to illustrate the firm's enterprise is that they co-operated in providing for the replacing of the pre-war German-made tungsten metal by an all-British product manufactured by High-Speed Steel Alloys, Limited, a company in the forming of which Messrs. Edgar Allen played an active part.

The business was founded in the year 1868 by the late Mr. William Edgar Allen, and, while dealing for a number of years with a general merchant trade, it also concentrated on the manufacture of tool steel and files. Mr. Allen sold a very large proportion of these products to foreign buyers and acquired a high reputation for these specialities of his in Italy, Spain, Portugal, among other countries. He subsequently purchased the old-established works and business of Messrs. Hoole, Staniforth and Co., whose experience in the manufacture of similar products was already extensive. In the year 1890, Mr. Allen was joined by Mr. Robert Woodward, the present chairman, and Mr. Alfred E. Wells, and in 1892 by Mr. F. A. Warlow, the present senior directors, and the firm was converted into a limited liability company under the present title; in 1891 the business was transferred to the present situation, on the south-east side of the road from Sheffield to Rotherham, at Tinsley. The works then rapidly expanded; a steel foundry was put into operation and one of its earliest results was the successful production of steel castings for dynamo magnets which, up to that time, had been made of wrought iron. The firm took over in 1903 the business of Messrs. Askham Brothers and Wilson, Limited, Yorkshire Steel and Engineering Works, Sheffield, a name well-known in connection with tramway track work generally, and with conveyors, ore crushers, disintegrators, air separators, &c. The acquisition of the Askham Brothers and Wilson business ensured for Messrs. Edgar Allen an outlet for their Imperial manganese steel for tramway work and the various component parts of crushing and grinding machinery which have to withstand heavy wear.

Mr. W. E. Allen died in January, 1915. It is fitting for us here to recall that, quite apart from his connection with the works he founded and which, with the help of his partners, he developed to their present status, his name is well-known and is revered throughout the country. He founded in Sheffield the Edgar Allen Institute for medico-mechanical treatment, an establishment of which he bore the entire cost. It is open to every working man. The treatment given in the Institute has proved an inestimable boon also to many of our soldiers wounded in the late war. Since its opening, in 1911, and up to November 30, 1920, as many as 5,717 civilian patients and 5,066 soldiers have been successfully treated. Mr. W. E. Allen contributed also very largely to the Sheffield Royal Hospital, Royal Infirmary, and other similar institutions. He, further, gave the Edgar Allen Library to the University of Sheffield. This library was illustrated in the issue of *The Builder* for December 31, 1920, in which it is styled "the gift of the late Edgar Allen, the founder of one of Sheffield's large companies," our contemporary adding that it has accommodation for 25,648 volumes in the library and for 97,698 volumes in the stack-room. Amongst Mr. Allen's numerous legacies was one of 50,000*l.* to the university.

The Edgar Allen works as they now stand are shown in the plan, Fig. 1. The older part is bounded by the road from Sheffield to Rotherham and by the Sheffield and South Yorkshire Canal. The newer portion is on the opposite, north-west side of the road and was commenced by the transfer of the Askham plant above referred to; it has been gradually built up on a prearranged plan which is only now approaching completion. It comprises, as will be seen, two large steel foundries. What we may style a third portion of the plant, and one which has recently been put into operation, is located to the south-west of the older works, on land fronting Shepcote-lane, as shown in Fig. 1 on the opposite page.

We may conveniently commence our description of Messrs. Edgar Allen's establishments by dealing first with this latter section. It has been set apart exclusively for the manufacture and assembling of railway and tramway special track-work. The section is divided into two distinct departments dealing respectively with railway and with tramway work, each department having its own designers. All castings for tramway work, such as crossings, points, vee-pieces, drain-box lids, tongues, anchor grips, &c., are manufactured by the firm of their Imperial manganese steel. The manganese steel rails are obtained from manganese steel ingots also cast by them and rolled at outside works under Messrs. Edgar Allen's supervision.

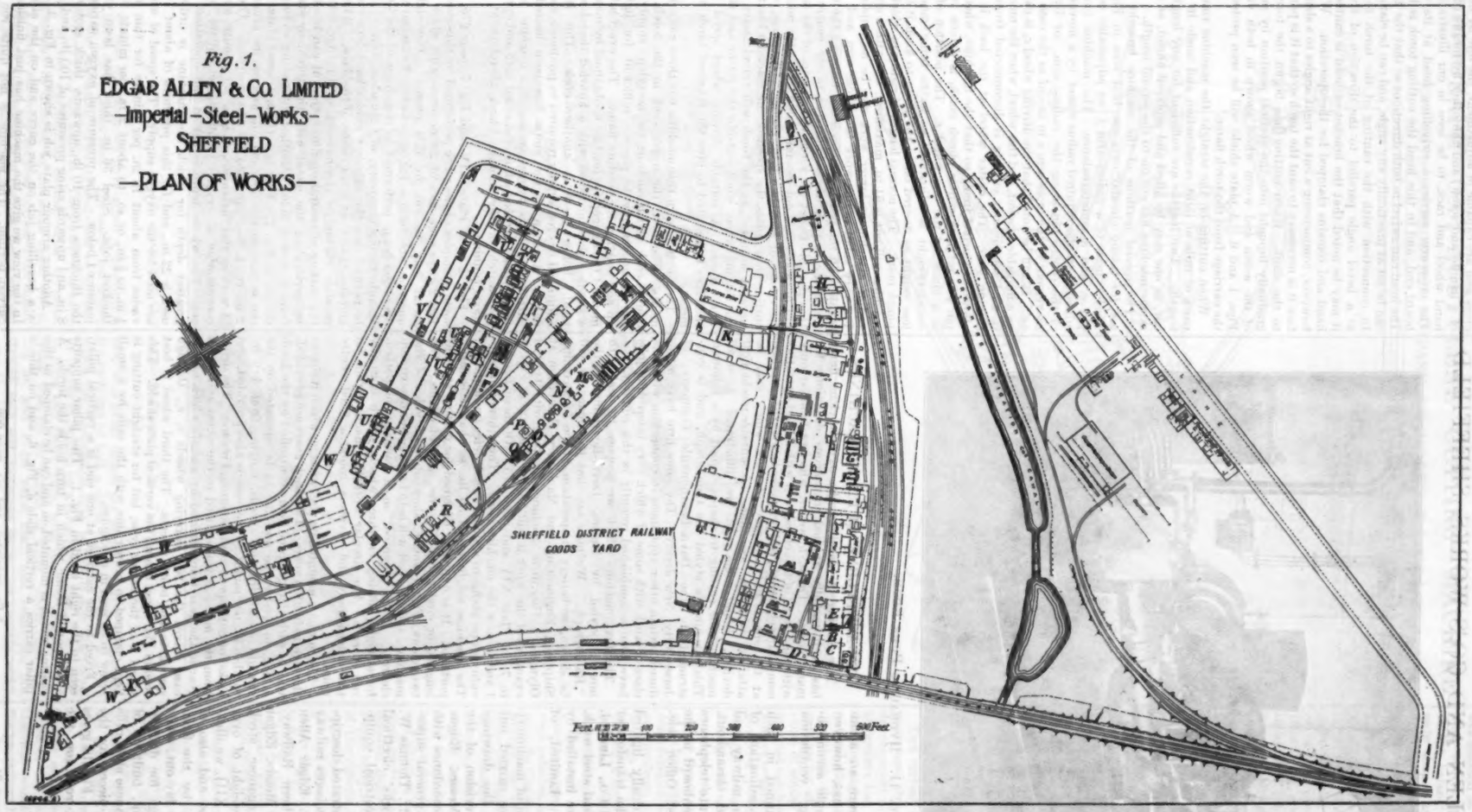
The site, triangular in shape, has an area of 14½ acres, the base running alongside the Sheffield and South Yorkshire Canal, one side fronting on to Shepcote-lane, the remaining side being parallel with the Sheffield and District Railway, from which it is intended to lay in a siding at an early date; this siding will give access both to the railway and to the other departments of the Imperial Steel Works on either side of the Sheffield-Rotherham-road. The whole site was used at first as a tip for the steel works' refuse and has been raised from the original formation to an average height of 15 ft. Great care was therefore exercised to reduce the weight of the buildings in every possible way consistent with efficiency. In order to meet this condition, and to make for rapidity of erection a steel-framed construction was decided upon, the columns with brick-filling between them being supported upon suitably designed reinforced concrete foundations. In designing the buildings, special consideration was given to the following points. The roof glazing was arranged to give the maximum daylight possible without sun-glare; all the shops and offices are adequately heated by steam and low-pressure hot water respectively, and the sanitary arrangements are of first class order. Figs. 2 to 5, on Plate XI, illustrate the constructive details of the railway and tramway shops.

At the present time the buildings comprise a large machine and grinding shop to be jointly occupied by the two departments engaged upon the construction of railway and tramway special track work. There are, further, a construction shop, two separate groups of offices, an electric transformer and boiler-house, and various auxiliary buildings such as stores, time-offices, an ambulance room, &c.

The machine and grinding shop is divided longitudinally into two separate bays, one 375 ft. long, 160 ft. wide and 23 ft. 6 in. high to the eaves, and one 425 ft. long, with the same width and height. The roof is covered on the north side by Mellowes patent glazing, and on the reverse side by asbestos-cement corrugated sheeting, supported upon angle steel purlins. Footwalks have been provided inside and outside for ease and safety in cleaning the roof glass. The combined floor area of the building is 63,258 sq. ft., the roof glazing has an area of 41,000 sq. ft. The shop is served by three electric 2-ton overhead travelling cranes in each bay, and is adequately equipped with hydraulic presses, pumps and accumulators, grinding and drilling machinery and other requisite machine tools. The whole of the line shafting, except where the machines are direct-coupled to motors, is carried upon self-aligning ball-bearing pedestals. The main drives are taken through Brampton silent chains from alternating-current motors to the line-shaft and by belt for the countershaft and final drive. The floors are paved with old oak timbers jointed with pitch and tar.

Other interesting shops in this department are the point shop, which we illustrate in Fig. 6, Plate XII, and the construction shop illustrated in the view Fig. 7. The pump-house is illustrated in Fig. 11, page 274. The construction shop has been specially designed to facilitate the convenient, safe and rapid handling of the material required in the lay-out and fitting-up of special track work. The building is 150 ft. long, 80 ft. wide and 23 ft. 6 in. high to the eaves. The floor area is 11,612 sq. ft.; the roof glazing has an area of 5,500 sq. ft., and the side glazing an area of 1,281 sq. ft. This shop is served by one 2-ton electric overhead travelling

THE WORKS OF MESSRS. EDGAR ALLEN AND CO., LIMITED, SHEFFIELD.



REFERENCES.

A. Crucible pot making.
B. Coke crucible furnace.
C. Gas crucible furnace.
D. Siemen's gas crucible furnace.
E. Steel ingot store and warehouse.
F. Annealing stoves.
G. Transformer house.
H. Annealing furnaces.
J. Fettling shop.
K. Sand sheds, research laboratory, and firebrick stores.
L. Sand-mixing plant.
M. Electric furnace, crucibles and transformer house.
N. 3-ton converters.
O. Blower house.
P. Casting pits.
Q. Electric furnaces.
R. 10-ton and 3½-ton electric furnaces.
S. Annealing furnaces.
T. Stores.
U. Shot-blast plants.
V. Hydraulic testing machines.
W. Pattern stores.
X. Experimental shop.

crane, the gantry carrying it being projected a further 150 ft. out into the yard, beyond the end of the shop, the said end being closed by four Kinnear steel rolling shutters arranged to be easily operated by one man. In addition to the power crane, a hand-operated travelling crane at a lower level is provided to handle work being drilled or bent. One side of the shop is also formed of Kinnear shutters arranged to open up over the entire length of the side, in 50-ft. bays or any less opening, in multiples of 12 ft. 6 in. The shop is completely equipped with grinding machinery, rail benders, drilling machines, &c. On the canal side is an extensive rail stores served by two overhead hand-operated travelling cranes, by which means the rails can be easily and rapidly carried from stock into the shop. A narrow-gauge railway runs from the grinding and machine shop to the construction shop.

The offices are of plain stock brickwork, no

MESSRS. EDGAR ALLEN AND CO.'S WORKS, SHEFFIELD.

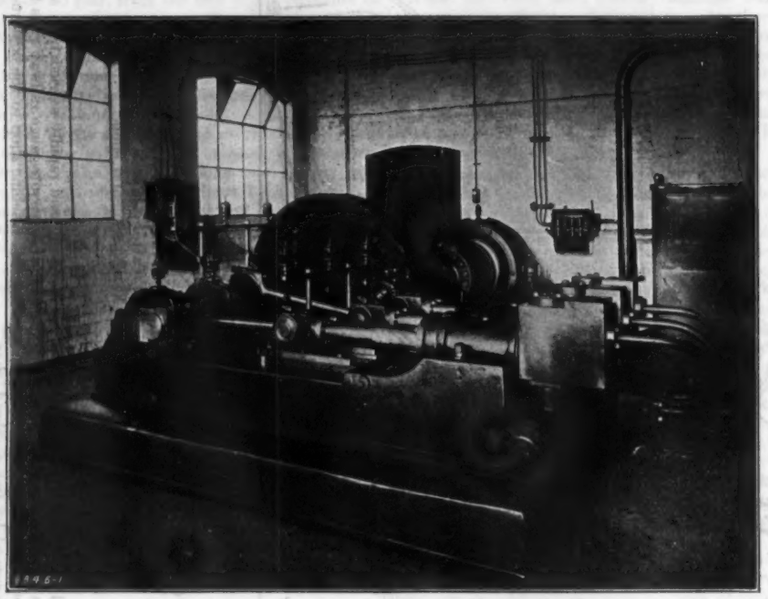


Fig. 11. Hydraulic Pump Room.

attempt having been made to secure an architectural effect; every consideration has, however, been given to the provision of ample accommodation, adequate lighting, heating, ventilation and sanitation.

The office building has been planned in such a manner as to secure proper co-ordination of all the various offices dealing with railway and tramway track-work, and is fitted throughout, together with the shops, with private telephones worked through the automatic switchboard in the Imperial Steel Works' offices. Post Office telephones are provided in addition.

The shops and offices are electrically lighted off the corporation mains through the transformer house. Messrs. Francis Morton and Co., Limited, supplied and erected the constructional steel work, while the heating arrangements were installed by the Brightside Foundry Company, Limited, of Sheffield.

The foundations, masonry, erection of machinery shafting, hydraulic plant, &c., were carried out by direct labour. The whole of the drawings details, specifications and the supervision of the construction were the work of Messrs. Edgar Allen's Engineering Department, in accordance with preliminary designs and under the general superintendence of the works' engineer, Mr. Thomas W. Barley, Mr. E. H. Furnival, the works' electrical engineer, having charge of the electrical equipment.

In a former issue* we gave an illustrated description of a large and intricate double-scissors railway crossover, manufactured by Mrssrs. Edgar Allen for the Buenos Ayres Great Southern Railway. The rails used in this crossover were Messrs. Edgar Allen's Imperial patent-rolled manganese steel, 100-lb. flange rails, having a total weight of over 100 tons. In Figs. 8 to 10, on Plate XIII, we illustrate more recent work of this class, and also of tramway trackwork, manufactured by the firm, Fig. 8 showing a complete tramway lay-out, while Fig. 9 illustrates diamond crossings for double-gauge tracks, angle 11 deg. 19 min., built up of Edgar Allen's Imperial rolled manganese steel rails with their cast manganese steel V-pieces, for the Antofagasta (Chili) Bolivia Railway. Fig. 10 gives an interesting view of the track-work for the Chapeltown car depot, Leeds.

(To be continued.)

* See Engineering, vol. xcvii, page 94.

OXY-ACETYLENE CUTTING MACHINES.

The cutting of metal by the oxy-acetylene flame has been usefully applied in various directions for many years. Those, however, who are familiar only with hand work of this class, even with skilled operators comparatively rough, will probably be greatly surprised at the speed and accuracy of work which may be attained with the assistance of suitable mechanical devices. Some time ago we illustrated a small machine* for cutting to shapes copied by a follower. This machine is styled the Camograph, and is constructed by the Davis-Bournonville Company, of Jersey City, New Jersey. The same firm have introduced certain other appliances in connection with this class of work with some of which very interesting jobs have been accomplished recently in this country.

The first machine which we propose to deal with now is styled by Messrs. Davis-Bournonville the "Radiograph." We may say that this machine will be shown, we believe in operation, at the forthcoming Shipping, Engineering and Machinery Exhibition at Olympia. This little machine, together with typical examples of the work it will do, we illustrate in Figs. 1 to 7, on Plate XIV and page 275. Of these figures, 1 and 6 show the machine itself. The others illustrate various operations to which we shall refer immediately. The machine weighs about 50 lb., so that it is easily portable. It is expressly designed for cutting straight lengths, or circles, or, of course, arcs of circles. The two views, Figs 1 and 6, show opposite sides of the machine, and this fact will help to make our description clearer. It is mounted on a carriage supported, for straight cutting, on three wheels, which normally run on rails. For circular work the machine runs on two wheels only and revolves round a fixed centre point.

The motor is mounted on the carriage, which it drives through reduction gears. Two back gears are provided, which, with change-speed gears controlled by the knob a, Fig. 6, enable the machine to be operated on the straight at 20 different speeds, ranging from 1·6 in. to 21·6 in. per minute. Reverse is also provided, and locks for both speed adjustment and reverse The drive from the motor is transmitted to the worm and worm gear b, the gear being carried by a shaft which in this case drives the two carrying wheels c, c_1, through sprockets and tooth wheels. The third wheel is best seen in Fig. 1 just behind the vertical plate shield. This wheel is of the caster type, but for straight cutting is kept clamped in proper line with the rails by a small screw to be seen in our figure.

Fixed to the carriage at one end is a vertical pillar, seen to the right hand in Fig. 1. This pillar supports a compound frame which in turn holds the torch. A casting which is mounted on and can be clamped to this pillar carries a vertical slide d, Fig. 6, and on this is arranged the sliding cross-arm e. Both slide and cross arm are capable of adjustment, the one by means of a handle and screw, and the other by means of the hand wheel and rack, to be seen in our illustrations. The cross-arm carries a swivelling head at its outboard end, and in this head the cutting torch is held. The head can swivel in both directions so that the torch can be set at practically any angle, and can be clamped. In connection with the canting of the torch to cut at a bevel angle parallel to the direction of travel, it may be noted that the bracket or head is canted by hand and remains clamped for the operation. When, however, commencing a cut at right angles to a slanting face it is necessary to cant the torch so that it is parallel to the slant. When cutting has begun the torch is gradually brought into the vertical position by means of the worm and worm wheel shown in both views, Figs. 1 and 6. A plate shield will be seen protecting the carriage from the torch flame.

When cutting on the straight the machine runs on pairs of rails of light construction and made in 5-ft. lengths. Two lengths are sufficient for any length of cut, as one may be lifted and replaced ahead, as soon as the machine has got on to the second length.

The special portions of the machine brought into use for taking circular cuts are best seen in Fig. 6. They consist of a radius arm f, an adjustable centre pin g, and a counterbalance. The machine can be adjusted to the required radius either by a movement of the centre pin along the radius arm, or by the movement of the cross-arm e in or out as the case may be. It will be noted that the driving wheel c_1 is carried on a movable bracket, and this wheel, when the machine is used for circular cutting is disconnected from the driving gear. The caster wheel at the back is also allowed to swivel freely so that the machine, when the pin g is set in a centre punch mark, is driven round in a circle by the one wheel c. The position of the counterweight is adjustable so as to bring more or less weight as desired on to the pin g to keep it in its punch mark. The normal length of radius to which the machine will cut is 51 in. maximum, but with a special radius attachment larger work can be accomplished. For very small radius work the whole arm and slide is taken off the pillar, and reversed, bringing the torch inside the driving wheel and close to the centre pin. It is possible to get the torch within 2 in. of the latter, but normally it is not recommended to use the machine for circles of less than 6-in. radius. Of course, when cutting to a radius the speed of the machine has to be suitably adjusted as the torch will travel faster than the driving wheel when outside the latter and slower when inside. A suitable driving wheel speed must therefore be selected to give the required torch movement.

The torch used in this machine has three gas adjustments. The first, the upper cock in the torch, is a double cock which controls the acetylene supply, and the oxygen supply to provide sufficient for lighting up and starting the heating flame. The exact adjustment of the oxygen for heating is obtained by means of a needle valve furnished with a knurled thumb screw head. Below these is another cock. This is the additional oxygen supply required to produce a cutting flame. As soon as the metal has been heated the cutting supply is turned on and the machine begins to function, as this cock is connected with and operates the switch of the motor, which therefore at once starts running.

Figs. 2 to 5, Plate XIV, and Fig. 7, page 275, show some examples of the work performed by this machine. Fig. 2 gives some idea of the neatness with which thick metal may be cut by this means. The slabs in question are frames for an electric locomotive, the operation being performed in the shops of the Jeffrey Manufacturing Company, of Columbus, Ohio. It will be noticed that the axle-box guides have been cut out and also blocks out in the centre of the slabs. Wherever possible cutting is commenced at an edge. But in the cutting of central openings, the cut can be started by perforating the metal with the torch, or starting from a drilled hole. Another interesting example is shown in Fig. 7. This is a 16-in. armour plate, while the section on the floor cut off, and on the ground, is 2 in. thick, and intended for test coupons. The rate of work in this instance was 4 in. per minute, and the consumption of oxygen ½ cub. ft. per square inch of cut. The whole depth is cut in one operation. The greatest depth for which the machine is ordinarily used is 22 in., and for this pressures of about 140 lb. are used for the oxygen supply. The speed of working varies from about 18 in. per minute for thin metal, ½ in. to ¼ in. or so, to about 2 in. per minute for the thickest jobs. Steel 36 in. thick has been cut as instanced below. The pressure of oxygen varies with the thickness from 10 lb. upwards, thick sections of 8 in. and upwards using pressures of 100 lb. and more.

Another armour plate job is shown in Fig. 3. This is a bevelling job on the curve and on the straight. In the view we give the machine has just finished the curved portion. The machine is not quite the same

* Engineering, vol. cix, page 606.

RADIOGRAPH OXY-ACETYLENE CUTTING MACHINE.

THE DAVIS-BOURNONVILLE COMPANY, JERSEY CITY, N.J., U.S.A.

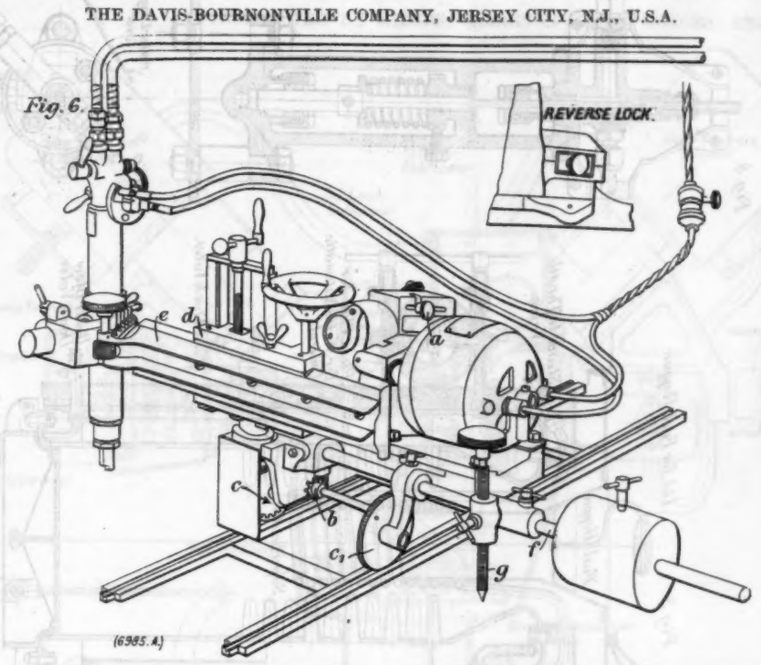


Fig. 6.

FIG. 7. 2-IN. SLAB CUT OFF ARMOUR-PLATE 16-IN. THICK.

model as that of which we have given a description above, but is on the same lines. The radius rod is seen towards the left-hand. Two typical bits of circular work are shown in Figs. 4 and 5. The former illustrates the use of the machine in cutting discs of plate. Attention may be directed to the small caster wheel, which is clearly shown at the near corner of the shield. The remaining illustration is of circular pieces cut out of slabs of steel 9 in. thick. These discs are cut at the rate of 5 lineal inches per minute, taking 20 minutes for each cut of half a circle. The variety of work to which the Radiograph may be put is also illustrated by its use in cutting up a large forged slab, 12 in. thick, to form two crank webs, with balance weights. The crank was for an engine of 24-in. stroke and had 15½ in. and 15-in. main shaft and crank-pin fits. Overall each web measured 66 in., its greatest width over the balance being 46 in. At the crank-pin end it was finished to a radius of 16 in. and this, with various other curves, gradually increased to the 46-in. width at the balance end. The slab was cut up and the webs shaped at a speed of from 3 in. to 3½ in. per minute, the torch cutting to within ¼ in. of finished dimensions. In another instance, a riser, 36 in. in diameter, weighing 30,000 lb., was cut off a casting for a 7,500 ton forging press in a little over 1 hour.

In cutting a roll shank of 0·60 carbon steel, a cut 45 in. long through a thickness of 18 in. was accomplished at the rate of 2 in. per minute. The pressure of oxygen used was 125 lb. and the consumption 720 cub. ft., giving an area cut per cub. ft. of 1¼ sq. in. In another job, on 0·30 carbon steel, an anvil casting was cut through, the thickness being 8 in. and length of cut 24 in. 90 lb. pressure was employed for the oxygen, the consumption of which worked out at 60 cub. ft., giving 3·2 sq. in. per cub. ft. The cutting speed was 3 in. per min. The acetylene pressure is about 5 lb. per sq. in.

It may be pointed out that stepped cuts can be made without interrupting cutting when the machine is arranged for working on a straight line. This may be accomplished by allowing the motor to traverse the machine on the rails up to the step and then switching the motor off and running the cross-arm out or in by the hand wheel at the proper cutting speed, re-starting the motor when the new line has been reached. It is also possible to run from the straight off on to curves, and *vice versa*. This operation is performed without the rails and by screwing down the centre pin into the punch mark when it is reached, sufficiently far to raise the wheel c_1, Fig. 6, off the plate.

(To be continued.)

THE CLARKSON STEAM LORRY.

THE earliest of the self-propelled vehicles to run on roads used steam as their motive power, but with the development of the internal-combustion engine, steam altogether lost its place in road transport except for traction engines and some of the heavier lorries. Its natural advantages, however, are considerable in many directions, the flexibility of the steam engine and its pertinacity of working under almost any conditions short of actual breakage having no counterpart in the internal-combustion engine. These features have always retained for the steam engine the position of a powerful potential competitor with its rival, even though for some years it seemed to have suffered an almost total eclipse, so far as the bulk of road transport is concerned. Another, and very important advantage of the steam engine lies in the comparative cheapness of its fuel, especially if coke or anthracite is used. This consideration has become of more and more importance as petroleum products have risen to many times their pre-war price and consequently it is not surprising to find a good deal of attention being given to the question of utilising steam propulsion for a greater proportion of the traffic on roads.

The name of Mr. Thomas Clarkson has for a long time been associated with the development of steam road vehicles, and many of our readers will be familiar with the Clarkson steam omnibuses which until recently worked on various London routes. These vehicles were not withdrawn for any mechanical defect, but were transferred to more lucrative employment in the country, where they now furnish a regular transport service between certain towns and villages. They used liquid fuel for steam raising, but their designer has now developed a type of vehicle which burns coke, and which in many respects marks so great an advance upon previous practice that it is worthy of a somewhat detailed description. The new vehicle, fitted with a wagon body, is illustrated in Fig. 1, page 276, an outline of the chassis is given in Fig. 2, and details of the engine, boiler, &c., are shown in Figs. 3 to 12, on pages 276 and 277. It is manufactured by Messrs. Clarkson, Steam Motors, of Chelmsford, Essex.

Except for the presence of the chimney, in Figs. 1 and 2, the vehicle might almost be mistaken for an ordinary motor lorry, and the resemblance is indeed much more than superficial. It contains change-speed gear constructed on the ordinary motor-car lines, and the operating levers for this and for the brake are arranged exactly as in a motor vehicle. The pedals, moreover, correspond as well, so that the Clarkson chassis may be operated immediately by drivers who have no previous experience of steam-driven vehicles. As will be explained later, the boiler is controlled automatically both as regards its rate of producing steam and its supply of feed water, so that the driver has practically nothing more to do, or to look after, than if the vehicle were of the ordinary petrol type. The similarity in appearance to a petrol vehicle is further enhanced by the condenser which takes the place of the usual radiator and is of practically identical construction. It should be noted that the provision of a condenser is a considerable advance upon general steam wagon practice, as it allows the

STEAM LORRY.

CONSTRUCTED BY MESSRS. CLARKSON STEAM MOTORS, ENGINEERS, CHELMSFORD.

FIG. 1.

Fig. 2.

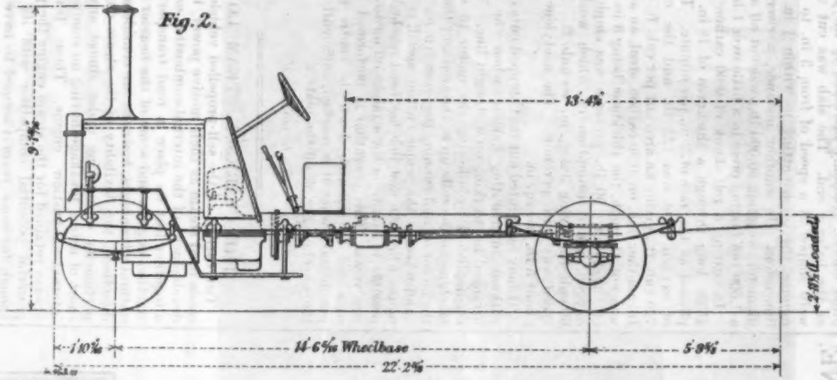


Fig. 3.

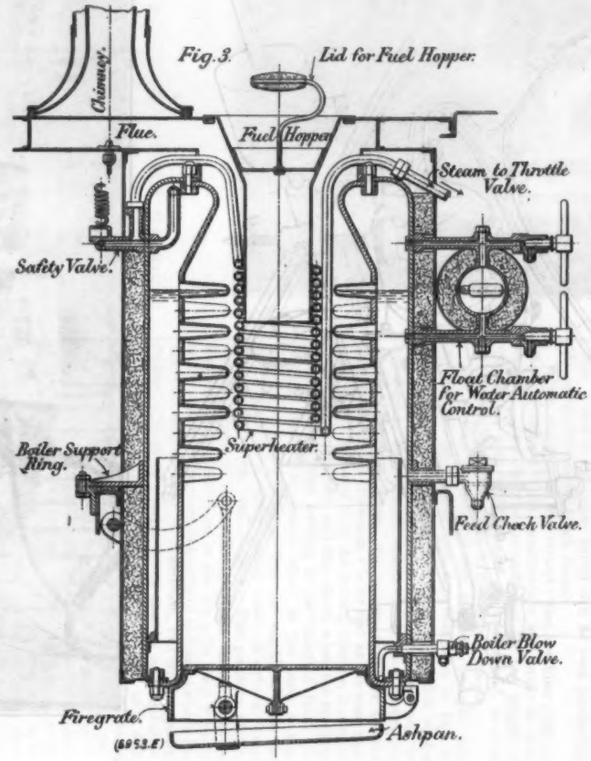


Fig. 8.

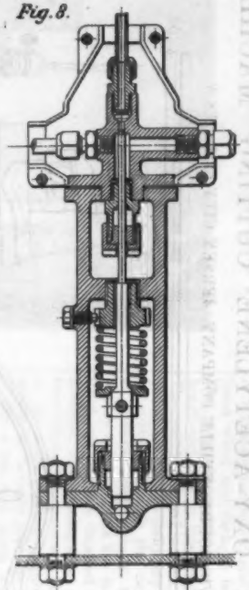


Fig. 9.

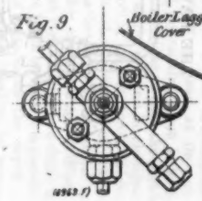


Fig. 4.

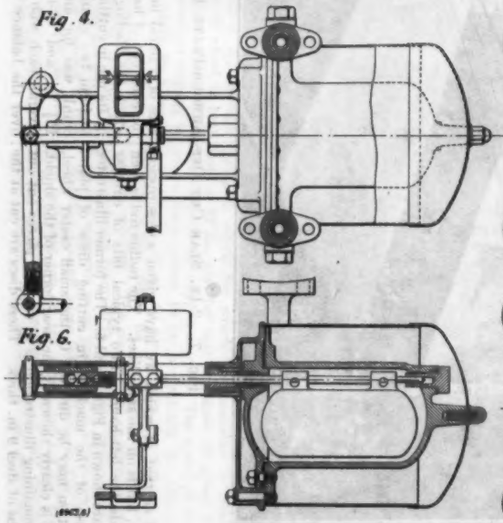


Fig. 5.

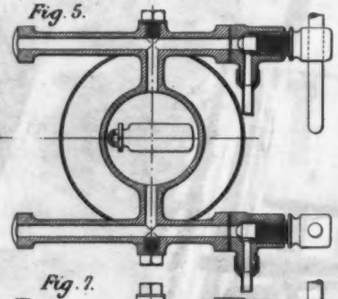
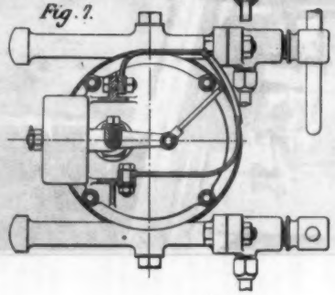


Fig. 6.

Fig. 7.



ENGINE FOR STEAM LORRY.

CONSTRUCTED BY MESSRS. CLARKSON STEAM MOTORS, ENGINEERS, CHELMSFORD.

Fig. 10.

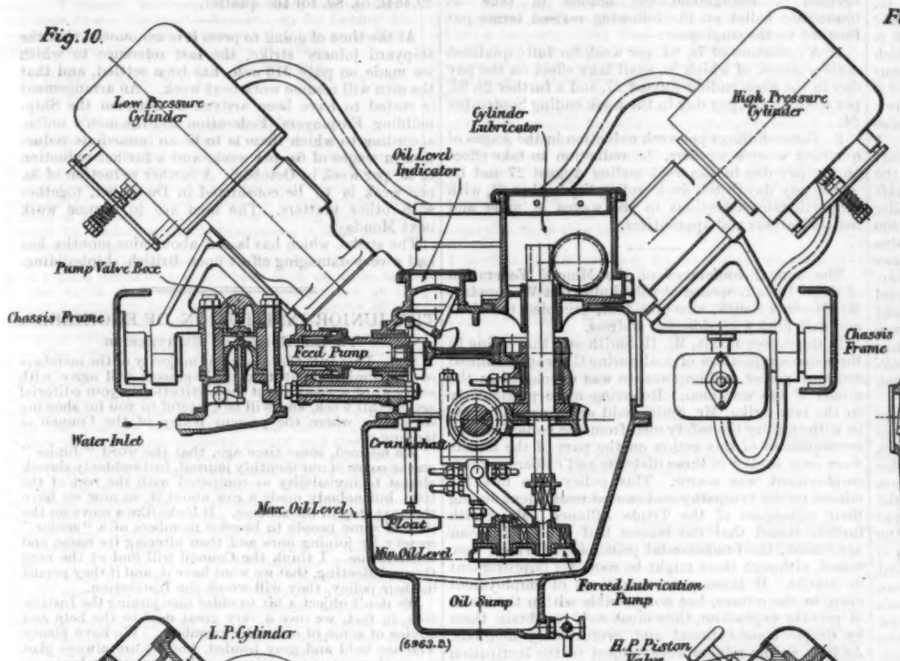


Fig. 11.

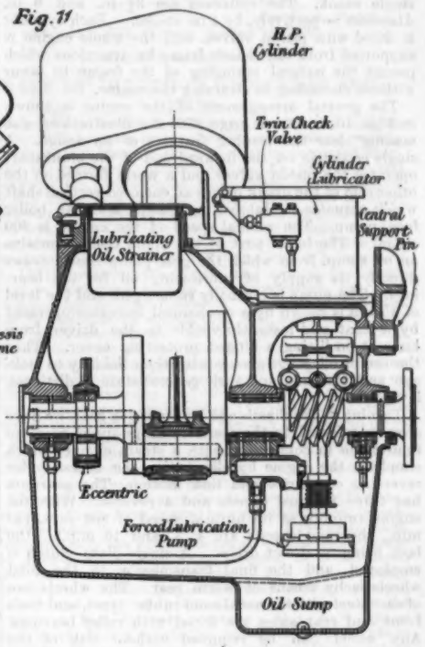
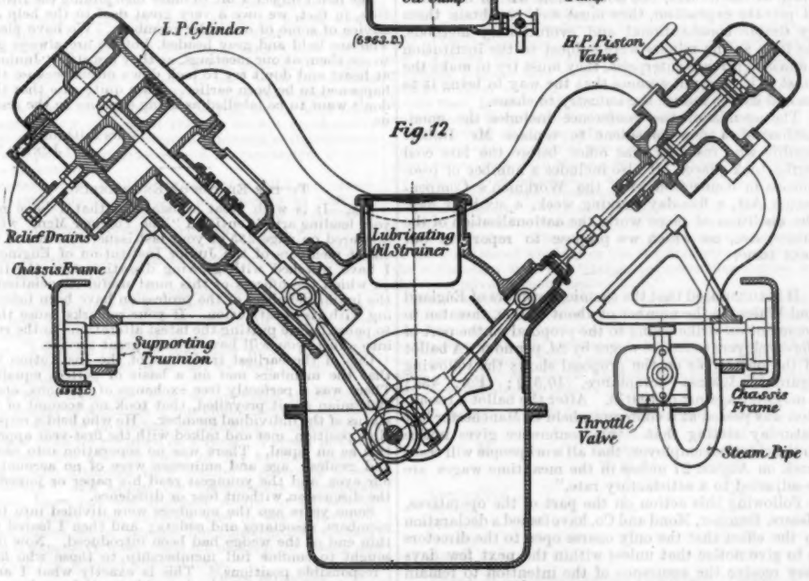


Fig. 12.



vehicle to travel long distances without replenishing its water and greatly reduces the deposit of scale in the boiler, with a consequent increase of efficiency and reduction in the time and labour required for boiler cleaning.

One of the most interesting parts of all steam vehicles, because of the variety of the troubles to which it may give rise, is the boiler. The new Clarkson boiler, shown in section in Fig. 3, page 276, is of very original design, and having been constructed in the light of lengthy experience of such things it would appear to be free from the particular defects which have beset so many of the attempts to produce a boiler suitable for the conditions of road transport. The boiler is probably unique in being free from any riveted or welded joint. It is composed essentially of two pieces of solid drawn cylindrical steel pipe, flanged in the manner shown and fastened together by studs. The joints are made by means of copper rings, and by undoing the nuts, the inner part can be entirely withdrawn for inspection or cleaning. There are no boiler tubes at all, the necessary heating surface being obtained by conical pressed steel thimbles projecting inwards from the walls of the inner cylinder. These thimbles are inserted into reamered holes and are all tightened in place simultaneously by the hydraulic pressure used to test the boiler. At first a slight beading was left on them to prevent any danger of them being ever forced through the plate, but this has proved to be entirely unnecessary as the highest pressure that the boiler will stand fails to force them inwards by more than a minute fraction of an inch. The working pressure in the boiler tends to tighten them in place and we understand that no trouble from leakage has ever been experienced.

It might be thought that there would be a liability for scale to accumulate inside the thimbles, as the latter are blind-ended, but experience shows that this does not occur. Indeed, as an experiment, the far end of the interior of a thimble has been plugged with artificial scale which in course of time was gradually washed away by the action of the water. This action has been studied in a glass model and it appears that a definite circulation, inwards along the lower side of the thimble and outwards along the upper, gives place under certain conditions to a pulsation of the water which has a cleansing effect on the interior of the thimble.

The feed water enters the boiler on the outside of an annular shield which prevents it coming immediately into contact with the inner shell, the arrangement being clearly shown in Fig. 3. The boiler heating surface is 37·2 sq. ft. and the grate area 1·57 sq. ft. The steam passes away from the highest part of the boiler by means of a pipe forming a long spiral coil, which acts as a superheater. The normal working pressure of the boiler is 300 lb. per sq. in., and the temperature of the steam from 620 deg. to 650 deg. Fahr. Steam can be raised in 15 minutes from cold water by the use of forced draught, and in 20 minutes to 25 minutes by natural draught. The water supply to the boiler is regulated automatically, and it requires no attention on the part of the driver. The mechanism will be understood from Figs. 4 to 7, on page 276. A float chamber, carrying a solid steel float, counterbalanced by an external weight, is in communication with both the steam and water space, as shown in Fig. 3. When the float rises above its normal position it lifts the suction valve of the feed pump and stops further delivery of water. The position of the float at any time, and thus of the water level in the boiler, is indicated by a pointer working in a quadrant in full view of the driver.

In all such devices dependent upon the action of floats, it is essential that any friction which would oppose the movement of the float should be reduced to a minimum, otherwise the operation of the apparatus will be erratic, or may even cease altogether. In the present case the float spindle has to be packed by a steam tight gland, which, incautiously tightened, would seriously interfere with the sensibility of the apparatus were it not for a most ingenious arrangement of Mr. Clarkson's which completely eliminates the effect of such friction. This consists in giving a continuous to-and fro motion to the spindle by means of the lever, shown in Fig. 4, which is operated from the engine. A consideration of the "triangle of forces" will show that the least tendency of the float to turn the spindle will cause an actual rotation of the latter if a longitudinal force sufficient to overcome the stuffing-box friction be applied. Thus for all practical purposes the mechanism is frictionless however tightly the gland be screwed up.

The regulation of the boiler pressure is effected by the device shown in Figs. 8 and 9, on page 276. Live steam acts upon the lower end of the spring-controlled piston, and, acting in opposition to the spring, it holds to its seat the small valve formed by an extension of the piston rod. This valve controls a jet of steam in the chimney which induces a strong draught through the fire. If the steam pressure drops below normal, the spring opens the valve and the fire is rapidly stimulated to meet the demands upon it. Like the water-regulating device, the pressure regulator demands no attention, and it certainly maintains a wonderfully constant working pressure under varying conditions of road and traffic. The vehicle may indeed be left unattended for hours with the engine turning slowly

as the lubrication, water level and steam pressure are all perfectly maintained automatically.

The engine used on the Clarkson steam vehicle is compound and is of the two-cylinder double-acting vee-type, both connecting rods being coupled to a single crank. The cylinders are 3¾ in. and 6 in. diameter respectively, by 4 in. stroke. Each cylinder is fitted with piston valves, and the whole engine is supported from the chassis frame by trunnions which permit the natural springing of the frame to occur without distorting or straining the engine.

The general arrangement of the engine is shown in Figs. 10 to 12, on page 276, the illustrations also making clear the leading features of its design. A single eccentric on the forward end of the crankshaft operates the piston valves and a worm formed on the other side of the crank drives an enclosed vertical shaft which actuates the lubricating pumps and the boiler feed pump. The normal speed of the engine is 800 r.p.m. The lower part of the crank casing contains an oil sump, from which the gear pump shown draws directly its supply of lubricating oil for the bearings. The pump is normally submerged, and the level of the oil is shown by a mechanical indicator operated by a float and instantly visible to the driver from his seat on lifting a hinged protecting cover. Thus the use of oil gauge glasses with their liability to leakage and fracture, and their general state of dirtiness, is avoided.

Turning to the chassis and transmission gear, we have already referred to the use of change-speed gear, an innovation in connection with a steam engine, which simplifies the engine by eliminating the necessity for reversing eccentrics and link motion. The gear-box has three forward speeds and a reverse. With the engine running at its normal speed of 800 revs. per min., the road speeds are 4, 8, and 16 m.p.h., the last being a direct drive. A single-plate clutch is employed, and the final transmission to the road wheels is by means of worm gear. The wheels are of cast steel with the usual solid rubber tyres, and both front and rear axles are fitted with roller bearings. Any wheel can be removed without risk of the bearings being damaged by dirt or other causes. Steering is effected by means of a worm and wheel mechanism, enclosed and self-lubricating, no bell-crank being used.

The chassis of the Clarkson lorry is only slightly heavier than that of a petrol-driven lorry of equal carrying capacity, and it compares favourably with the latter in point of price. The saving in the cost of fuel is, however, so great that comparisons between the types in this respect, are overwhelmingly in favour of the steam vehicle. With coke at 40*s.* per ton, and a consumption of 4·5 lb. per mile, which is what the 3-ton Clarkson lorry requires when working 80 miles to 100 miles per day on long-distance traffic, the fuel cost per mile works out at less than 1*d.*, or about one-fifth the fuel cost of a petrol vehicle. On local traffic with a daily mileage of 30 or less, and many stops and waits, the fuel consumption works out to about 7·3 lb. per mile, the cost being just over 1½*d.*, as compared with 6*d.* or more for a petrol lorry. Owing to the condensation of all the steam used, except that required for blowing up the fire, the water consumption is small, and replenishment is only needed once in 100 miles or so.

The practice of condensing very greatly minimises the amount of boiler cleaning required and the comparative absence of scale tends to the maintenance of a high steaming efficiency. Indeed, the economy of water and the benefit to the boiler, constitute the main objects of condensing. A high vacuum is not aimed at, and though as much as 12½ inches is sometimes obtained, the usual vacuum is more like five or six inches. The oil, which is carried from the engine cylinders in the exhaust steam is completely eliminated from the condensate before the latter is returned to the boiler. This is effected by means of a small Davis-Perrett oil extractor operated by the current from the dynamos and battery which furnish the lighting of the vehicle.

A vehicle of the type we have illustrated and described has been subjected to a month's test at the Royal Naval Dockyard, at Portsmouth. It was driven throughout by one of the yard drivers, and we may quote the following sentences from the official report of the trials: "Generally the result of the month's experience has demonstrated that the lorry is highly satisfactory, both as regards economy, ease of handling and reliability of operation. The mechanism is considered to be, on the whole, less liable to failure or interference with its continued efficiency, than that of the petrol lorry. During the period under report, there was no mechanical failure, and the ingenious automatic appliances worked without a hitch. Having regard to the ease of starting and of handling, it is considered that this car could be efficiently operated by a woman or a disabled soldier, in which respect it has an advantage as compared with petrol lorries of the same size."

INDUSTRIAL NOTES.

The Joint Industrial Council for the Printing Trades held meetings last week to consider the question of wages reductions. After lengthy discussions it was decided to recommend the unions to take an immediate ballot on the following revised terms put forward by the employers:—

1. A reduction of 7*s.* 6*d.* per week for fully qualified male workers, of which 5*s.* shall take effect on the pay day in the week ending August 27, and a further 2*s.* 6*d.* per week on the pay day in the week ending September 24.

2. Three shillings per week reduction in the wages of qualified women workers, 2*s.* reduction to take effect on the pay day in the week ending August 27 and 1*s.* on the pay day in the week ending September 24, with proportionate reductions in the wages of male and female learners and apprentices.

The annual conference of the Miners' Federation of Great Britain opened at Llandudno last Wednesday. Mr. Herbert Smith, vice-president, occupied the chair and delivered a presidential address.

In the course of this, Mr. H. Smith said that owing to the economic position of coal during the war, an unreal sense of power and importance was developed in the minds of the workmen. Referring more particularly to the late strike, Mr. Smith said an error was made in withdrawing the safety men from the collieries; the consequences of this action on the part of the miners were seen to-day in those districts and collieries where employment was scarce. This policy also lost the miners public sympathy and caused resentment among their colleagues of the Triple Alliance. Mr. Smith further stated that the miners had entered into an agreement, the fundamental principles of which were sound, although there might be room for improvement in details. If there were conditions of employment open to the miners, but not possible within the limits of private capitalism, they must seek to obtain them by simple constitutional and evolutionary methods. As long as the miners were subject to the institution known as private enterprise, they must try to make the most of it, and not assume that the way to bring it to an end was to reduce the industry to chaos.

The agenda of the conference includes the nomination of a new president to replace Mr. Robert Smillie who resigned that office before the late coal strike took place. It also includes a number of resolutions in connection with the Workmen's Compensation Act, a five-day working week, a six-hour day, the abolition of piece work, the nationalisation of the mines, &c., on which we propose to report in our next issue.

It is announced that the chemical workers of England and Wales, to the number of about 30,000, threaten to come out on strike owing to the proposal on the part of the employers to reduce wages by 2*d.* per hour. A ballot of the operatives on the proposal shows the following figures: Against acceptance, 10,510; For, 434; a majority against of 10,076. After the ballot a resolution was passed at a conference held in Manchester last Saturday stating that "this conference gives notice to the chemical employers that all workpeople will cease work on August 27 unless in the meantime wages are re-adjusted to a satisfactory rate."

Following this action on the part of the operatives, Messrs. Brunner, Mond and Co. have issued a declaration to the effect that the only course open to the directors is to give notice that unless within the next few days they receive the assurance of the intention to remain at work from a sufficient number of operatives to enable manufacture to be carried on, the works will be closed as from the 27th instant.

The monthly report for August of the United Society of Boiler Makers and Iron and Steel Shipbuilders states that expenses taken from monthly sheets for July showed a total of £110,073 2*s.* 9*d.*, as against an expenditure of £36,286 from monthly sheets for June. The report adds that this heavy increase shown for July is due to the more complete returns of branch expenditure for that month, in conformity with instructions given in the preceding report.

The Secretary of the London Iron and Steel Exchange, Limited, in his report of the meeting held last Tuesday, states that the prices of British finished steel are still too high to compete successfully with the prices quoted by continental manufacturers. German, Swedish and other foreign merchants are invading the overseas markets and are offering material at ridiculously low prices. It is assumed that these quotations are the outcome of speculation upon exchange movements and a fall in freights. This has an unsettling effect upon British business.

The account of income and expenditure given in the latest report of the United Patternmakers' Association, for the quarter ending on the last meeting night in June, 1921, shows a total expenditure of 59,224*l.* 6*s.* 6*d.*, and a total income of 29,740*l.* 0*s.* 10*d.*, giving a loss of 29,484*l.* 5*s.* 8*d.* for the quarter.

At the time of going to press it is announced that the shipyard joiners' strike, the last reference to which we made on page 216 *ante*, has been settled, and that the men will resume work next week. An arrangement is stated to have been arrived at between the Shipbuilding Employers' Federation and the men's union, according to which there is to be an immediate reduction in wages of 6*s.* per week, and a further reduction of 3*s.* per week in October. A further reduction of 3*s.* per week is to be considered in December, together with other matters. The men are to resume work next Monday.

The strike, which has lasted about nine months, has had a very damaging effect upon British shipbuilding.

THE JUNIOR INSTITUTION OF ENGINEERS.

To the Editor of Engineering.

Sir,—I am sure that the great majority of the members of the Junior Institution of Engineers will agree with every word you say about the Institution in your editorial article this week, and will be grateful to you for showing so clearly where the present policy of the Council is landing us.

We noticed, some time ago, that the word "Junior" on the cover of our monthly journal, had suddenly shrunk almost to invisibility as compared with the rest of the title, but nobody made a row about it, so now we have the next step in the scheme. It looks like a move on the part of some people to become members of a "senior" society by joining ours and then altering its name and constitution. I think the Council will find at the next General Meeting, that we wont have it, and if they persist in their policy, they will wreck the Institution.

We don't object a bit to older men joining the Institution, in fact, we owe a very great deal to the help and advice of some of our older members. We have plenty who are bald and grey headed, but we are always glad to see them at our meetings, as they are still "Juniors" at heart and don't try to look down on us because they happened to be born earlier. I am quite sure that they don't want to be labelled as being superior to the rest of us.

Yours faithfully,
"Junior."

To the Editor of Engineering.

Sir,—It is with great satisfaction that I have read your leading article entitled "The Younger Men," which appeared on page 255 of your last issue. As one of the oldest members of the Junior Institution of Engineers, I have watched with growing dissatisfaction the lines on which the officers of this most useful Association of the junior members of the profession have been tampering with its constitution. If your remarks cause them to pause before putting the latest alterations to the rules into effect, you will have done a great service.

One of the earliest traditions of the Institution was that the members met on a basis of perfect equality. There was a perfectly free exchange of opinions, and a Bohemian spirit prevailed, that took no account of the status of the individual member. He who held a responsible position, met and talked with the first-year apprentice as an equal. There was no separation into castes and grades; age and eminence were of no account in our eyes, and the youngest read his paper or joined in the discussion without fear or diffidence.

Some years ago the members were divided into full-members, associates and cadets; and then I feared the thin end of the wedge had been introduced. Now it is sought to confine full membership to those who hold "responsible positions." This is exactly what I anticipated. It tears up the old traditions by the roots.

There are other Institutions which engineers can join if they want to be graded according to age and standing in the profession. Where white beards and bald heads are a necessary qualification for a seat on the Council Bench, and where papers are read on the great works with which engineers improve the geography of the world. It is right and proper that in such places that the younger members should look up to and respect their elders, and only the front benches should join in the discussions.

But the Junior Institution of Engineers is quite another galley. It will gain nothing by trying to reform itself on the lines of these older societies, and it has much to lose. Catering for the rank and file, it has a much wider field from which to draw its members, and though it might easily surpass them in the numbers, there is no reason why there should be any overlapping of functions. It is futile to try and make it a kind of 1½-in.-to-the-foot working model of the senior Institutions. It sacrifices the dignity which its age and past success have earned for it.

Hitherto the Junior Institution has received the ungrudging assistance and support of the other great bodies and their members. Many of the most exalted ornaments of the profession have filled its Presidential Chair; its status and traditions have been recognised and approved, and its members have received hospitality in five Continents; and so I trust the Council will

hesitate and consider very carefully before they indulge in any tinkering with the foundations which we older members laboured carefully to consolidate.

Having been a member for 35 years, I have long since felt it right to leave the management to younger hands, and I am genuinely sorry to find myself not at one with them. I cannot, however, refrain from urging delay, and hope to see the matter brought up for further discussion at the next Annual General Meeting, and a lively debate, especially by the younger members.

Yours truly,

40, Chancery-lane, W.C.2. A. H. TYLER.

TO THE EDITOR OF ENGINEERING.

SIR,—I am, alas, not one of the younger men, for I have been a member of the Junior Institution of Engineers for over 35 years. But to me and the many of my brother members who, holding "posts of responsibility," nevertheless object to being inflated into a state of spurious seniority, your leading Editorial of August 12, dealing with the Institution is most grateful and comforting.

Someone has blundered. The intention I am sure is good; good intentions, it has been said, do more harm in the world than malice. The management of the Junior Institution has been extremely vigorous of late years. The average age of its members has risen in company with the growth of its numbers. Some of the men who were not in the Institution (or its forerunners) in their teens, have never quite fully realised that the Institution is not for them primarily. They are welcome, indeed; but only so long as they bear in mind that they are not there for their own sakes alone, but mainly to help the younger men. Otherwise their true status is that of paying and respected guests, and the Institution is not their spiritual home; though it may become such if they are the kind of senior who is capable of sinking his seniority temporarily. There is the self-conscious senior (not of remarkable seniority or of important standing as a rule), who thinks that membership of what I have heard him term a "boys' society," is beneath his dignity. So it is. But he misses the point; it is the Civils or the Mechanicals or the Royal Society that he needs. Not a body whose components should essentially be boyish. There is in our Junior Institution no place for the bumptious senior, or for the even more bumptious junior, either of whom would like to think (but he will be mistaken) that membership of a Junior Institution of Engineers makes him by the mere lapse of years, a senior entitled, as such, to swagger over the Junior Member, and to rank with the seniors of other Institutions. It will *not* thus exalt him.

Nor is there any place for the real senior who takes so large a view of himself that he cannot comfortably mingle once a month, or even once a week with beginners and unimportant subordinates in his profession, or may be, in his employ.

I suspect these kinds of person of a mild and unconscious snobbishness, manifest as a desire to puff out our Junior Institution into a *quasi* senior Institution. He may succeed in doing so perhaps; but it will occupy a somewhat undignified place in the tail of the seniors, instead of being where it undoubtedly is now, at the head of all Junior Institutions.

Look at the list of our famous Past-Presidents. No really senior Society of any sort can show a finer array. They took a real and active interest in us (I knew many of them), because we were as an Institution essentially junior. I cannot imagine that they would have taken any particular interest in us had we been merely make-believe seniors.

You have seen, Sir, that we, perhaps unwittingly, are in danger of a change in our character, and you have pointed out the unwisdom of allowing this change to be made or to be recorded in a Rule. I speak not only for myself, but also for many of my brother members abroad, who although they occupy "positions of responsibility" and enjoy the emoluments appropriate thereto, have not the slightest desire to be labelled as being larger than anybody else in the Institution. By all means let us increase our subscriptions; everything is expensive now. But let us keep for young and old alike our ancient youthfulness.

Yours faithfully,

W. J. TENNANT.

MILDNESS AND TOUGHNESS.

TO THE EDITOR OF ENGINEERING.

SIR:—During the last few years a good deal of discussion has been devoted to the indications of impact tests on notched metal rods, and there appears to be a growing tendency to regard the word "toughness" as one denoting the particular property which is disclosed by these tests.

The specimens are torn in two by a blow from a swinging weight. The process of tearing consists almost entirely of distortion; a substance breaks when its distortion exceeds a characteristic angle θ, which, like other physical properties, depends upon the temperature and pressure. The value of θ in materials classed as "steel" may be anything from practically zero to, say, half a right angle, i.e., the range of this quality is considerable; the strength of "steel" may be regarded in comparison as constant. Impact tests cannot be ranked among the most precise physical determinations, and the indication they give will apparently be one of θ, with possible minor complications due to differences of strength and other properties.

The old "tensile test" offers an alternative method of measuring θ, and is in some respects preferable to the impact test; the "percentage reduction of area" can readily be converted into degrees of distortion, whereas even the younger readers of ENGINEERING might find it difficult to quote the cosine of a foot-pound. The suggested identity of "impact value" and "percentage reduction of area" is satisfactorily confirmed by the recent report of the Steel Research Committee of the Institution of Automobile Engineers, which, so far as your correspondent is aware, is quite the most important record of impact tests accessible to the general public; the experiments show that, with one or two exceptions (where a property other than θ has an appreciable influence) "impact value" can be inferred from "percentage reduction of area"—and vice-versa—for the whole range of steels commonly used in the automobile trade.

Occasional exceptions are to be expected, and can readily be accounted for; the utility of impact tests must lie in their normal indication, which corresponds to a property whose importance merits something better than a Greek letter as a name: Clerk Maxwell has defined θ as "mildness" (or "mildness" as θ), and Maxwell and Mr. A. Mallock agree that toughness is something else: I have been unable to find anything contrary to their view in the writings of earlier authorities.

I hesitate to address you, Sir, on a mere question of language, but the rational study of solidity is already sufficiently hampered by the indiscriminate association of words and things. Humpty Dumpty told Alice (scornfully) that "When I use a word it means just what I choose it to mean—neither more nor less," but he had to admit that there was an inconvenient clamour on Saturday nights when the words came round "for to get their wages." The regular employment of "mildness" would at least save overtime payments to "toughness."

Yours faithfully,

J. INNES.

4, Eslington Road, Newcastle-on-Tyne.
August 11, 1921.

RECIPROCATING PUMPING ENGINES *VERSUS* TURBINE-DRIVEN CENTRIFUGAL PUMPS.

TO THE EDITOR OF ENGINEERING.

SIR,—In your issue for July 8, on page 74, you printed a paper contributed by Mr. Hugh Lupton to Section III, of the Engineering Conference convened by the Institution of Civil Engineers, containing a remarkable comparison between the performances of some reciprocating pumping engines and some turbine-driven centrifugal pumps. After carefully examining the figures it seems to me that, in the interests of those who will read them uncritically, they should not pass unchallenged.

I am aware that properly to discuss the comparison between the two classes of pumps, and to present conclusions at variance with those given in your issue, it would be necessary to accompany any remarks with data in support of the views expressed.

Unfortunately, I have no such data from actual installations and it would require much time to collect the information. Therefore, one must confine oneself to the question of whether or not the data given supports the contention that the "triple reciprocating engine is the most advantageous proposition."

In the oral discussion on the figures, Mr. J. H. Barker pointed out that the cost of foundations and buildings had been neglected and the case for the turbine driven pump was seriously prejudiced thereby. The capital cost for machinery alone was not discussed. Using the data given by Mr. Hugh Lupton, the machinery costs can be calculated as follows:—

TABLE I.—*Triple Expansion Pumping Engines.*

Name.	Capital cost per W.H.P.	Total Capital Cost.
	£	£
Leeds City	47	7,880
Bristol	56	9,410
Rosario	41	8,560
Odessa	37	14,050
Rand	34	15,660

TABLE II.—*Turbine-Driven Centrifugal Pumps.*

Name.	Capital cost per W.H.P.	Total Capital Cost.
	£	£
Estimate (1) ...	30	4,320
Bristol Trial. De Laval	13·15	3,420
Estimate (4) ...	18·35	5,290
Estimate (5) ...	15	6,480
Estimate (7) ...	12·62	7,270

Immediately these figures are examined they present a totally different value. The entire "comparison" depends upon one single actual installation (Bristol Trial) and four estimates. The actual installation is a De Laval plant with a 14 to 1 gear reduction, and every one of the estimates is a geared set, which, of course, carries transmission losses with it.

The capital costs of the triple expansion sets are all obviously pre-war prices, and apparently the correction of figures to 1918 prices has only been applied to the unfortunate "estimates" for turbine-driven plants. The Margate engine is the only case where a post-war capital cost could have been included for the triple sets, and here we find a significant blank.

Sir, I beg to submit that the case for the turbine-driven centrifugal pump has been hopelessly prejudiced.

Perhaps the subject should not be left without pointing out that Mr. Lupton's comparison is essentially one between reciprocating steam engines and small steam turbines, and must not be confused with the issue of reciprocating pumps *versus* turbine pumps. The natural drive for a turbine pump of moderate output is an electric motor, and a combination of this sort can generally compare favourably with almost any other pumping unit.

Yours faithfully,

OWEN A. PRICE.

5, Cavendish-place, Troon, August 16, 1921.

RATE OF DIFFUSION OF CARBON INTO IRON.

THERE is still some uncertainty as to the way in which carbon diffuses into iron. In the cementation process direct contact between the iron and the powdered charcoal is essential. According to Le Chatelier and Bonnerot no cementation takes place in the absence of any gases in a vacuum, whilst Guillet and Griffiths obtained some penetration in a vacuum when the charcoal was pressed against the iron. Iris Runge, who has been investigating the problem at Göttingen (Zeitschrift für Anorganische Chemie 115, pages 293–311, February 21, 1921), believes with Giolitti and Astorri, that gases play an important part in the penetration, but that solid penetration is also possible. In order to study the rate of diffusion of carbon into iron, she had to work with carbonaceous gases. While Giolitti had in similar researches analysed the successive layers of an iron wire heated in a carbonaceous gas, Iris Runge relies on the increase of the electric resistance of the wire and on microscopical examination. She makes the assumption that the increase in resistance will be proportional to the amount of carbon absorbed by the iron; the assumption is somewhat questionable, but seems justified by her experiments, especially considering that iron does not, under her experimental conditions, take up more than 1·5 per cent. of carbon at near 1,000 deg. C.

The wires used in the experiments were 0·5 mm. in diam., 50 cm. or 25 cm. long, wound to a spiral of 2·5 cm. length, and enclosed in an electric furnace. By copper leads, 2 mm. in diam., the wires were led to a Wheatstone bridge for resistance measurements accurate to 0·001 ohm., and taken every few minutes. The wires, mostly electrolytic iron, were first heated in a current of hydrogen or nitrogen until the furnace temperature and the resistance had become constant; this took about two hours, during which the resistance rose to about ten times its original value. The current of the respective gas was then turned on; the gases tried were: coal gas, as such or diluted with hydrogen or nitrogen; vapours of hexane, benzene, toluene, petrolether and methyl-alcohol, likewise diluted. The change in resistance observed would of course partly be a temperature effect. Sometimes a change in resistance was noticed, attributable to carbon; when there was a change, the wire would mostly be covered with loose sooty carbon; this was especially noticed with hexane, and was least noticeable with toluene. When there was no change in the resistance, little or no carbon would be found in the iron on subsequent examination. It was clear that the presence of hydrogen facilitated the penetration of carbon into iron, though the results were not very concordant. The rise of the resistance was generally rapid at first; within about 40 min. constant conditions would be attained. The absorption of 1 per cent. of carbon increased the resistance of the iron at 920 deg. C. by 5·7 per cent., at 830 deg. by 7 per cent., at 18 deg. by 40 per cent., the increase being reckoned on the corresponding temperature. The diffusion co-efficient at 930 deg. C. was 2×10^{-7} sq. cm. per second, and with an active gas 0·6 mg. of carbon passed through 1 sq. cm. of iron surface in the first three minutes. There was no appreciable cementation below 700 deg., and the rate of cementation rapidly rose at higher temperature. The mixed crystals formed above 900 deg. consisted of cementite and pearlite.

PERSONAL.—The Bucyrus Company, excavating and mining machinery makers, whose headquarters are at South Milwaukee, Wisconsin, U.S.A., and who were formerly represented in the British Isles by Messrs. G. F. West and Co., announce that they have now opened their own office at 19, Iddesleigh House, Caxton-street, Westminster.

UTILISATION OF WASTE TIMBER AND COTTON STALKS.—It has been estimated that in the United States alone the quantity of wood waste produced annually in saw-mills amounts to 4,000 million cubic feet. Much of the wood at present wasted could be utilised for the making of paper pulp, turpentine, acetic acid, and other products. The question has recently received consideration in New Zealand, and it has been suggested that in some instances the waste might be used for paper-making in place of imported wood-pulp. In order to ascertain the suitability of certain New Zealand timbers for this purpose an investigation has been conducted at the Imperial Institute. It was found that the timbers examined could all be used for the manufacture of paper pulp, but whether such an industry would be profitable in New Zealand would depend on purely economic factors, such as the quantity of waste wood available, its cost at the pulp-mill, the price of fuel and chemicals, &c. The Imperial Institute has also dealt with the problem of the commercial utilisation in cotton growing countries of the vast quantities of cotton stalks which are available every year and have to be removed from the field after the cotton crop has been gathered. Investigation at the Institute has shown that the stalks form a promising material for paper-making and that they might also be used for obtaining acetic acid, tar and charcoal by a process of dry distillation.

48-IN. RAILWAY WHEEL LATHE.

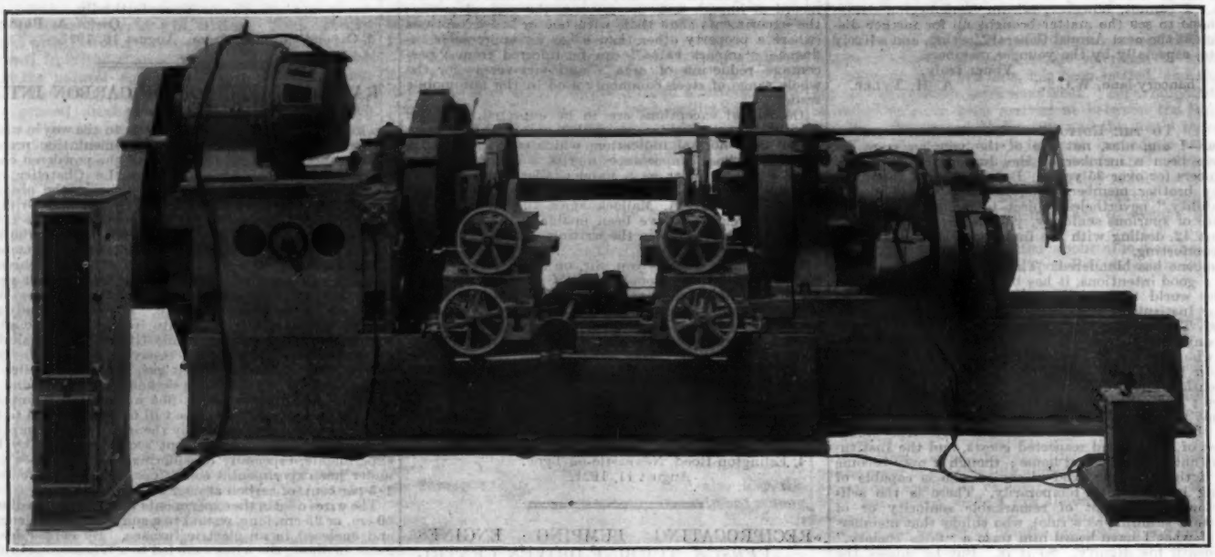


Fig. 1. View of Machine from Operator's Side.

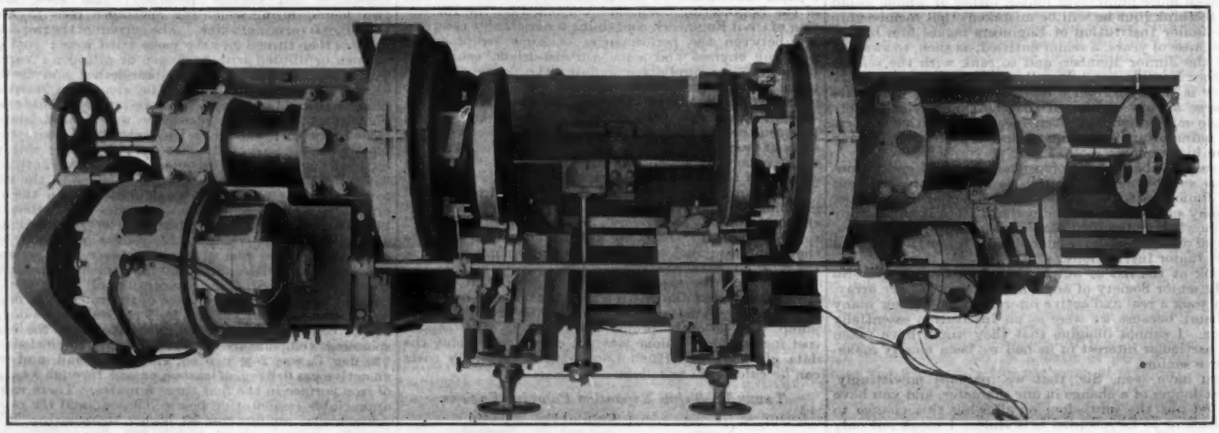


Fig. 2. View looking Down on the Machine from Above.

A design of heavy wheel lathe embodying various interesting features is being brought out by Messrs. Noble and Lund, Limited, of Felling-on-Tyne, in collaboration with Messrs. Alfred Herbert, Limited, Coventry. The latter firm will act as agents for these machines, the first of which has just been completed. This tool is illustrated in Figs. 1 to 5, on the present and opposite pages, and is a good example of progressive design. The machine in question is a 48-in. lathe for railway wheels. The view in Fig. 1 gives a good idea of the front appearance of the lathe with the 50-h.p. variable-speed motor mounted over the headstock to the left. Fig. 2 is a view looking down on the machine from above, while Fig. 3 is a view taken near the right-hand tool slide and the tailstock.

The lathe is arranged with push-button speed control, so that variation of speed may be instantly obtainable during a cut should the quality of the tyres require it. The control buttons are arranged normally on one of the tool slides, so as to be handy to the operator while watching his job, but in our illustrations the fitting is shown attached to the headstock. This fitting controls the starting and stopping of the machine in addition to speed control. Either alternating-current or direct current motors may be employed, driving direct. A gear-box is arranged to give two speed changes by means of sliding gears; these, with the variable control, allow of a range of speeds from 0·88 r.p.m. to 3·44 r.p.m. The motor reduction gears are of cast-iron with raw hide pinions.

The bed of the machine is a box casting weighing 12 tons. It is 30 in. deep by 22 ft. in length and 5 ft. 8 in. wide at the headstock end. The whole machine weighs about 35 tons. The driving shaft is of nickel-chrome steel, heat treated, and 6½ in. diameter. It is carried in four bearings, of which one is situated between the face plates as shown in Figs. 1 and 2. The main spindles are of close-grained cast-iron. They are hollow and of unusually large diameter. The front bearing is 16 in. in diameter by 24 in. long, and the rear 10½ in. in diameter by 14 in. in length, in each case, the thrust being taken at the back bearing by means of gun-metal plates, provided with pockets. The plates revolve in an oil bath and oil is picked up in the pockets and automatically lubricates the faces. The main driving gears for the faceplates are of cast steel and are double helical, being 7 in. wide. Four driving dogs are attached, fitted to each faceplate. These dogs have serrated grips set on wedge blocks, so that the heavier the cut, the stronger the grip they exert on the wheel.

The hollow main spindles are fitted internally with steel sleeves which can be used as push-out collet chucks. These sleeves are tapered internally at the end and the journals surrounded by split taper bushes are placed inside them. The internal sleeves are adjusted longitudinally in the spindles, and a centreing grip exerted on the journals by the large hand wheels at the outboard ends of the head and tail stocks, through a spindle and sliding screw, the latter working in a nut on the inner end of the sleeve. The sliding movement of the screw on the spindle is controlled by a strong spring, in order to minimise adjustments when a run of wheels and axles of the same size is being dealt with.

The tailstock is traversed on the bed by means of an independent, 7½-h.p. reversing motor which may be plainly seen in our illustrations, especially in Fig. 3. This operates through a train of reduction gears and a revolving nut on a fixed screw in the bed. The movement is controlled by a friction clutch, the upright handle lever of which is seen in front of the tailstock. The motor is mounted in a position in which it is well out of the way while remaining thoroughly accessible, The clamping of the tailstock when it runs up to the job is effected by wedge projections which are forced into sockets. One of the latter is on the right hand saddle, the other being placed on the rear slide of the bed. The saddles carry compound slides, capable of being swivelled through a sufficient arc to take any ordinary tread profile. The feed is arranged for through a small cross-shaft easily recognisable in our illustrations between the saddles. This shaft is driven from the main shaft by bevel gears. On its front or near end a small disc crank is mounted, and this drives ratchets on the two saddles as will be easily followed from our engravings. The amount of the feed is regulated by an adjustable slipper plate which lifts the pawl and prevents it picking up more than the desired number of ratchet

48-IN. RAILWAY WHEEL LATHE.

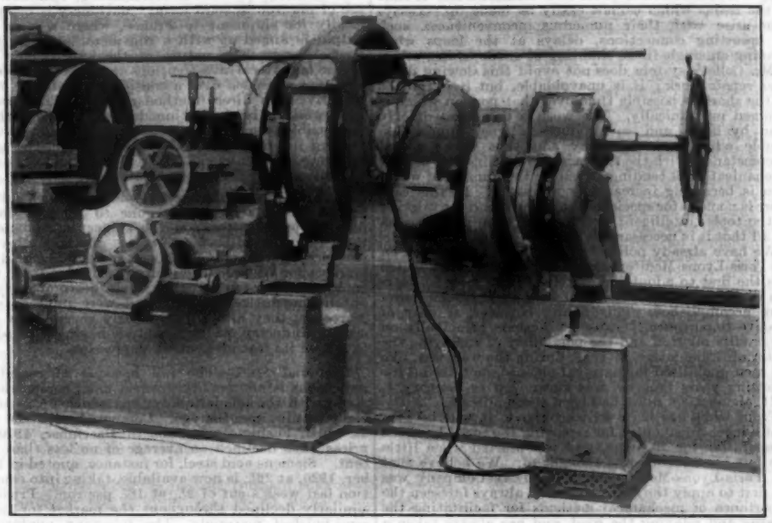
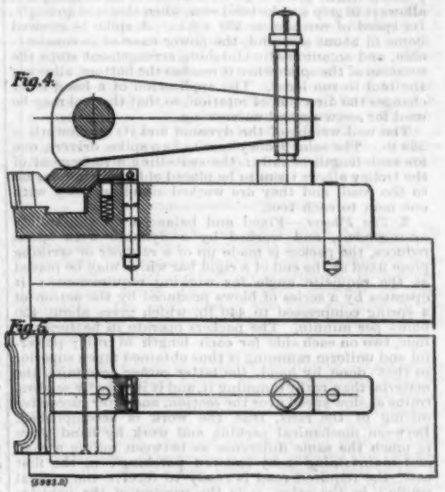


Fig. 3. Tailstock and Right-Hand Tool Slide.



teeth for each oscillation. The slipper adjustment is by a small worm and worm wheel, the control of which is effected by the small knurled disc heads to the right and left of the two main hand wheels of the saddles. The feed may be varied in this way from 0·11 in. to 0·66 in. per revolution of the work, the feed being applied six times during the complete revolution. The two saddles can, if necessary, be fed at different speeds with this arrangement. The feed is transmitted from the ratchet shafts through bevels to the longitudinal traverse slide. The turning tools and form tools are clamped by toggles, that for the form or profile finishing tool being illustrated in Figs. 4 and 5. Each is tightened by a single screw. The form tool and holder are rather unusual. The arrangement of the dovetail section of the tool, and of the wedging block enable divided tools to be used and quickly set or changed, should they be preferred to a single former.

The lathe will take wheels from 2 ft. 9 in. in diameter to 4 ft. diameter, and of any gauge from metre to 5 ft. 6 in. We are informed that a pair of 36-in. wagon wheels can be re-turned on this machine in floor to floor time of 18 minutes to 20 minutes, removing $\frac{1}{4}$ in. to $\frac{1}{2}$ in. on the tread. At the first operation the treads and flanges are rough-turned with a coarse feed, the finishing being accomplished with the full-width form tools.

NOTE ON MECHANICAL PERMANENT WAY REPAIRING PLANT.*

By Mr. Cartault, Honorary Chief Engineer of the Paris, Lyons & Mediterranean Railway Company.

The "Bulletin of the International Railway Association," published in 1920 two extracts from the American magazine *The Railway Review*, relating to mechanical apparatus for packing sleepers: A "Jackson" electric packer which was tested on January 8, 1920, before American engineers, and the "Imperial" pneumatic packer tried in 1913. We have also noticed in American and other publications descriptions of packing machines of various other systems.

In presence of the difficulties found in obtaining labour, and the exigencies of this labour, it is natural that mechanical processes which tend to reduce it and at the same time accelerate the work should be closely examined. However, according to the documents which lie before us, the suggested contrivances are new, and none of them have yet received the sanction accorded by experience, the period of their trial abroad not yet being over. The problem is, in fact, complicated and difficult to solve; one thing is to arrange for a section of track to try it on, another to fix an equipment on a line in operation and face all the difficulties and hindrances of every kind resulting from the running of the trains.

Besides, there is already in France not only a packing machine, but also a complete mechanical repairing equipment which has been in operation for the last twenty years and which has dealt with several thousand kilometres of lines in use. The whole of the apparatus of this equipment was invented, brought out, and improved by Mr. Albert Collet.

When Chief engineer of the permanent way of the Paris, Lyons and Mediterranean Railway Company, we began a trial of the system in 1901, and followed up its development until January 1, 1913—year of our retirement—during which time a length of 1,430 miles of the Paris-Lyons-Mediterranean system was relaid by means of the "Collet" apparatus. The use of it, which diminished greatly during the war, was however proceeded with, and by January 1, 1921, the length of relaying by mechanical means had risen to 2,000 miles. It should, of course, be understood that this refers to what was done on the Paris-Lyons-Mediterranean system only, but we know, without going into details, that it was used elsewhere in France and abroad, chiefly in Spain and Italy. Whatever else happened however, the two statements "Start of the system in 1901"—"length relayed 2,000 miles," show that we are not considering apparatus that is being studied or tried, but of apparatus that is in regular use and which has stood the test of time and entered into current practice.

As far back as 1904, a description of the "A. Collet" system appeared in the *Revue générale des chemins de fer*; in 1905 the report given by the Paris, Lyons and Mediterranean Company to its shareholders' meeting contained the following sentence which may be repeated:—"We have given a trial of, and hope to adopt in current practice, new methods of taking up and relaying the lines, and also mechanical packing of the sleepers which will reduce the delay to the running of trains that always occurs when the lines are under repair."

We have no intention of examining or criticising the apparatus described in the articles that appeared in the bulletin and mentioned above, but will only point out that the pneumatic method appears unsatisfactory, the use of compressed air necessitating a compressor, an air reservoir, air-tight tubing, and heavy and cumbersome apparatus which is difficult to fix and remove.

Besides, on a line with a heavy traffic such as that from Paris to Marseilles, the intervals of free time between the passing of trains are rare and of short duration. It is indispensable to be able to get ready for work in a few minutes and then clear the line; it is necessary to have tools that are relatively light, easily worked and strong, so that the men can fix or remove them quickly without accident, and of small enough size so as to be clear of the gauge when working in cuttings or along sustaining walls. As we shall see further on, one of the advantages, though not the least, of the "Collet" system is rapidity of putting down and removal, and ease in fixing the plant; in fact, no difficulties have been encountered in organising the arrangement even in the narrowest cuttings.

The mechanical equipment consists of:

1. The generating plant for the power required and cables for the transmission of the power to the tools; this is placed on the outside of line or in the recess of a retaining wall.

2. The spike drivers which can turn in either direction according as it is desired to unscrew the old spikes or screw in the new ones;

3. The packers with changeable ends adaptable for the different kinds of ballast;

4. A re-adzer for shaping and drilling, in place or in proximity to the plant, sleepers that may be used again;

5. Accessory apparatus such as, special lorries for carrying the material, machine for drilling the sleepers, rail driller used in cases where it is necessary to drill holes in rails, for instance, when it is required to fix stops to prevent longitudinal slipping.

Testing apparatus for work done; distance gauges; extractometer to measure the resistance to withdrawal of the screwed spikes; torsiometer giving the resistance to turning till the screw gives and turns free, and a declimeter to measure the resistance to pulling over the spikes and rails, and even an instrument for comparing the different methods of packing.

Finally, when necessary, a repair car small enough to be fixed on a platform and capable of undertaking all general repairs. We will examine successively these different apparatus.

1. *Power Generating Plant.*—This is an electro-generating plant capable of producing 34·5 h.p. and weighing 6,170 lb.; the engine of explosion type worked by petrol or benzol is coupled by means of a belt to a dynamo supplying continuous current at 240 volts. Two reservoirs containing petrol or benzol and water, enable it to work without refilling from five to ten days according to the length of its daily utilisation; cooling is done by air, and the whole of the mechanism is enclosed in a metallic dust and water-proof casing.

The method of shifting about and stabling is worth describing. The apparatus is fitted with:

1. Four flanged wheels of small diameter of standard gauge apart, and fixed in pivoted shackles: it runs along the rails after the fashion of a small truck. The shackles of the wheels can turn 90 deg. round their vertical axes; the wheels are, therefore, parallel or perpendicular to the lines.

2. An axle fitted with carriage wheels of large diameter; this axle is raised or lowered by means of a handle so that the apparatus is supported on the small wheels or on the large ones according to requirements; in the latter case it travels on the road like an ordinary cart. The apparatus having been placed on the rails is brought to the right of the place it has to occupy during the working of the plant; the carriage wheels are lowered, which raises the whole body and the flanged wheels; the shackles of the latter are turned through 90 deg. and two short lengths of rail are slid under crosswise to the road; the cart wheels are then raised and the apparatus resting again on the flanged wheels, is brought away from the line and placed on the outer side of the track, hardly five minutes being required for the operation. The apparatus is furnished with shafts, allowing it, in case it is required, to travel by road.

The cable through which the power is conveyed is made up of two high-conductivity copper wires $\frac{7}{10}$ in. diameter, divided into sections 165 ft. long, each being supported on a double ladder weighing 128 lb. fitted with telescopic feet in order to be adaptable to the inequalities of the ground. There are a stretcher and a drum on which the wire is wound when changing place; the wire is hung by insulating loops and the current passes the support by means of the cables. The dimensions of the ladders allow them to be fixed in the normal width between rails. By this means is arranged along the whole length of the plant, a continuous line of two wires on which run the trolleys carrying the current to the different tools.

For about the last two years a new system has been adopted with various "Collet" outfits which does away with the carrying arrangement and the ladders. The single electric generating plant has been replaced by three smaller and very light combinations which can be placed on or taken off the rails without difficulty: each combination fitted on its own trolley follows on the line, the spike fixing, spike withdrawing and packing implements to which it supplies the current through a ground cable of 16 ft. 5 in. to 19 ft. 8 in. long at the most.

2. *The Spiking Tool.*—The spiking tool like the packer is made up of three parts easily separated one from the other: The carriage, the electric motor, and the working tool.

The carriage is fitted with two pairs of swivelled wheels of standard gauge, and weighs 13 lb. The dynamo, which, like the lorry, is similar for all the appliances, rests on a framework fitted with a pivot which turns

* Reprinted from the "Bulletin of the International Railway Association."

in the lorry centre. This is its only connection to the carriage, so that the dynamo is easily fixed or dismantled; its weight complete is 231 lb. The working tool is joined to the framing of the dynamo by a cardanic suspension which gives it great freedom of movement, and allows it to grip a spike head even when this is at an angle. Its speed of rotation is 550 r.p.m. A spike is screwed home in about a second, the power exerted is considerable, and an automatic clutching arrangement stops the rotation of the spike when it reaches the bottom, allowing the tool to run loose. The application of a hand lever changes the direction of rotation, so that the tool may be used for screwing and unscrewing.

The tool weight of the dynamo and its framework is 364 lb. The same trolley carries two spike drivers, one for each length of raile; the swivelling arrangement of the trolley allows them to be placed obliquely in relation to the road, and they are worked simultaneously with one man to each tool.

3. *The Packer.*—Fixed and balanced on the trolley arrangement, and worked by a dynamo with speed reducer, the packer is made up of a rammer or striking piece fixed at the end of a rigid bar which may be placed at the requisite angle for working requirements; it operates by a series of blows produced by the action of a spring compressed to 440 lb. which gives about 450 blows per minute. The packers operate in batteries of four, two on each side for each length of rail; powerful and uniform ramming is thus obtained much superior to that done by hand, the latter rather cramming the material than really ramming it, and it is only by sending trains at slow speed over the section, and after successive raising of the rails, that the work is accomplished. Between mechanical packing and work by hand there is, much the same difference as between rolling a road and maintaining it by isolated patching; in the first case, the required road is ready to receive the normal traffic; in the other, it is the passing of the vehicles which gradually solidifies the material.

In a trial made on the Northern Company, a train travelled at 65 miles per hour over the track almost immediately after it had been rammed mechanically. It is, therefore, possible to re-establish the normal running speed as soon as the work is accomplished. For each kind of ballast, broken stone, sand, gravel, there is a corresponding special kind of ram head which is easy to change.

A packer with dynamo and frame complete weighs 352 lb., and rests, like the spike arrangement, on a trolley to which it is fixed simply by means of a pivot and central support.

4. *Adzing Machine.*—In a section under repair it is an obvious advantage to re-adze on the spot all the sleepers which can be used again; by this the bringing up of new sleepers and the stocking of old ones for later use is avoided, with the loss of time and labour which these operations entail.

The electric adzer travels on the rails and is placed in the station near the work in hand; it weighs 2,975 lb., and the adzing is done by a rapidly revolving milling cutter, thus avoiding saw marks and tearing the wood. Its turnover is from 1,000 sleepers to 1,500 sleepers per day.

Mr. A. Collet has also constructed a light re-adzing machine which can be used on the sleeper in position, working along the sleepers and requiring only 10 seconds to adze each one. The machine weighs in all 550 lb. (each motor being removable) and is fitted on the trolley system.

5. *Accessory Apparatus.*—We will not dwell long on the subject of accessory apparatus; we should, however, mention the special lorry which is so useful for transport, not only on the sections under repair, but also for maintenance work. It is made up of two trucks each weighing 352 lb., which rise very little above the rails; on these two trucks it is possible to place 150 sleepers, and on the level two men are sufficient to shunt them about with a load of 12 tons; it is hardly necessary to say that its bearings are fitted with balls, as are those of the other apparatus.

We have only a few words to say respecting the other accessories. The drilling machine for drilling on the spot the holes in the sleepers, is fixed on the trolley and worked by an electric motor; it weighs 132 lb., or, altogether, 375 lb. The rail driller is of the same weight.

The extractometer measures the resistance of the spikes to withdrawal; it registers up to 10 tons and weighs 13·8 lb.

The torsiometer shows the resistance to twisting, it registers up to 550 lb., and weighs 7 lb.

The declimeter indicates the resistance to pulling the spikes sideways; it registers up to 8,820 lb., and weighs 14·3 lb. Another declimeter indicates the resistance of rails to over-turning, it registers 55,000 lb., and weighs 176 lb.

The packingmeter is used to measure the resistance to compression by isolating the prism of rammed ballast on which the sleeper rests; the apparatus exerts a force of 5 tons and weighs 110 lb.

Finally, a gauge placed under the rails, thus allowing the trains to pass, checks their distance apart; its weight is 77 lb. for the Vignoles type of track.

To sum up, the "Collet" repair system forms a complete and homogeneous arrangement adapted to all the various circumstances that occur in repairing the lines; years of work and thought have been necessary to bring it up to its present state of perfection so as to be suitable for regular adoption.

We have given the weight of each apparatus in order to show that a few men in a very short time can either fix or remove them. As we have already pointed out, it is indispensable to be able to work during the shortest intervals between the running of trains, even as low as 15 minutes; without that, on busy lines, the work accomplished is insignificant, and the staff is uneconomically employed.

A repair job has naturally a great influence on the running of the trains, involving slowing down while running over the part under repair until this is found to be quite solid. When several parts in succession are being repaired, and this cannot be avoided over long stretches of line, there is a resultant loss of time to the trains which cannot easily be made up. Delays thus arise with their numerous inconveniences, such as upsetting connections, delays at the loops when running on single lines, shunting of goods trains, etc.

Mr. Collet's system does not avoid this slowing down over repair work; it is unavoidable, but it is limited to the shortest possible time over that portion which is rammed mechanically. The work is done more quickly than by hand, and so produces a very appreciable double advantage. We may add that under actual circumstances with the shortage and costliness of labour, mechanical work tending to reduce the number of workmen is becoming increasingly necessary. In this case there is no need for specialists to superintend the working of the tools; intelligent workmen are soon able to pick up all that it is necessary to know.

We have already pointed out the results obtained on the Paris-Lyons-Mediterranean Railway Company, which was the first to adopt the system. Beginning 20 years ago in 1901, with 2·5 miles of line, in 1912, 238 miles were accomplished. This figure, however, is only of relative importance, because it depends principally on the credits allotted and the possibility of supplying the material. The latter, in 1915, during the war, was, like the men, mobilised for national defence, and during the following years progress was slow. Up to January 1, 1921, about 2,000 miles had been accomplished.

From what has been written above, it will be seen that a mechanical outfit for repairing the roads has been in operation for 20 years, and was started when little else but hand labour was thought of. We believe that the Paris-Lyons-Mediterranean Railway Company was the first to apply the system: it had always foreseen the importance of mechanical methods for facilitating the making and relaying the road, and has always taken a great interest in furthering that object.

ELECTRIC ENERGY FROM WIND POWER.

An interesting method of tackling the problem set by the small wind power electric-generating plant has been brought forward by Messrs. F. A. Wilkinson and Partners, Limited, of Hatfield, Herts. In place of the usual fairly large diameter fan, or wind wheel, set at the top of a lattice tower, and driving a dynamo through some kind of gearing, Messrs. Wilkinson employ a number of small dynamos with impellers mounted directly on their spindles. The dynamos are carried at the top of the tower, which consists simply of a tubular pole with a tubular cross-bar on which the machinery is mounted. To obtain additional height, the pole may, of course, be mounted on the top of a building. An advantage claimed for this arrangement is that power may be obtained during high wind and gales. With the ordinary arrangement it is frequently necessary to disconnect the drive in periods of strong wind to prevent damage to the mechanism, or to prevent the storage battery being subject to too high a rate of charge.

The Wilkinson dynamos are each rated at 40 watts, and are self-regulating for battery charging. The cross-arm on which they are mounted is fitted with a swivel head and a vane which causes the impellers always to face the wind. Battery charging is commenced with winds of 15 miles an hour, and output and speed increase with increase in velocity of the wind. A feature of the system is an automatic cut-out, which makes, or breaks, the connection between the battery and the dynamos. The arrangement operates in connection with one of the dynamos, which is designed so that its armature has a small amount of end movement. A contact plate is fitted to the shaft, while there are a pair of contact fingers mounted on a support attached to the frame. When the velocity of the wind is high enough, the contact plate is forced against the fingers, making the necessary connection between the dynamos and battery, and conversely breaking the connection when the wind velocity falls below a predetermined value. The operation is entirely automatic.

City and Guilds of London Institute.—Mr. H. P. Philpot, B.Sc., A.M.Inst.C.E., Assistant Professor at University College, has been appointed to the Professorship of Civil and Mechanical Engineering at the Finsbury Technical College; and Mr. A. J. Hale, B.Sc., F.I.C., Chief Assistant in the department of Applied Chemistry, to the Professorship in that department. The entrance examination of the College will be held on Tuesday, September 20.

Boiler Rust.—In a paper contributed to the *Zeitschrift für angewandte Chemie*, 1921, pages 231 and 232, G. Bruhns discusses the iron rust of a deep red colour which had formed in a boiler fed with peat water. The rust consisted of iron oxide and calcium sulphide; there was no carbonate in the scale. As the feed water itself contained no iron, the rust was due to boiler corrosion, which was very uniform, by the peat water. The feed water was of low hardness and contained only traces of bicarbonate; it was not free from carbon dioxide, and it contained nitric and nitrous acid and organic acids (humin). Bruhns considers the carbonic acid and secondarily the nitric acid responsible for the attack of the iron, and the vapours of nitrous acid, driven off with the steam, responsible for the corrosion of the pipes. Such peat water should be treated with milk of lime, so as to be rendered slightly alkaline.

NOTES FROM SOUTH YORKSHIRE.

Sheffield, Wednesday.

Steel Experiments.—Sheffield manufacturers are watching very closely the progress of experiments in France, into a direct process of steelmaking, eliminating the use of pig-iron in solid form. Machinery is being made locally for shipment to France, where a large initial output is aimed at with a considerable saving in production cost. The nature of the experiments is not new so far as local investigations are concerned. Research work has extended over a considerable number of years to arrive at a direct method of steelmaking from ore. That work is being continued to-day. The authorities responsible, which include some of the biggest steelmaking interests in Yorkshire, maintain the greatest reticence, but enquiries show that reliable results are not anticipated in the immediate future.

The Steel Trade with America.—Four of Sheffield's best-known business men have gone to America to make direct representations on the subject of the proposed tariff revisions in that country as affecting alloy steels. America in the past has been one of Sheffield's best markets for special steels, but opportunity to do further trade on a substantial scale would be completely ruled out if the duties contemplated were imposed in full. Moreover, they aim a particularly severe blow at the crucible industry, which already is having a big struggle to get on its feet after acute depression.

Iron and Steel.—The full measure of recent price reductions is not readily grasped until comparisons are made with the official quotations which operated some eight or nine months ago. Compared with the figures at which business was done in December, 1920, steel prices have declined an average of no less than 40 per cent. Siemens acid steel, for instance, quoted in December, 1920, at 26*l.*, is now available, taking into consideration last week's cut of 2*l.*, at 16*l.* per ton. Prices have similarly declined throughout the market for raw and semi-finished materials. The following quotations of prices in operation in December, 1920, and to-day, respectively, offer a striking comparison:—Bessemer acid billets, 25*l.* 10*s.*—15*l.* 10*s.*; hard basic billets, 22*l.*—13*l.*; soft basic billets, 20*l.*—12*l.* Another move in the direction of stimulating production generally is the decline of 15*s.* per ton in blast-furnace coke, and 18*s.* in crucible melting coke. This brings blast-furnace coke to within comparable reach of the figures at which district pig-iron makers can produce economically in competition with foreign producers. Preparations are already being made for the relighting of a number of furnaces which have been idle for the past four months. Though the outlook is more hopeful, steelmakers do not anticipate any substantial revival before 1922. Mills, forges and press-shops are engaged on the average at not more than one-third of their normal capacity. Engineering concerns producing for the shipbuilding industry are undergoing a very trying period. A few outstanding orders are being worked off. The amount of business coming to hand is not sufficient to give any assurance of improved conditions when delayed contracts have been completed. There is eager competition for new business in the tool section. Substantial contracts are in hand for machine tools for export, but makers of hand tools have not yet been able to reduce quotations sufficiently to attract the big orders which foreign buyers are waiting to place. The current demand for builders' ironwork is sufficient to keep local foundries normally employed, but prospects are clouded owing to the uncertain outlook in the building trade. If financial arrangements can be satisfactorily concluded, Sheffield expects to open up a big business with Roumania in railway equipment.

South Yorkshire Coal Trade.—Confusion as to prices is holding back business. There is still a strong demand by railway users for hard steams. Cobbles and nuts are only moderately firm; special quotations are available to buyers offering substantial business. The demand for manufacturing fuel is nothing like equal to the output. The accumulation of stocks at pits is holding up business. The demand for housecoal is not up to expectations. Merchants allege that the refusal of a large section of the public to place orders for housecoal will have the opposite effect to that anticipated. Prices, they state, may temporarily languish, but if there is a rush to place winter requirements, quotations will inevitably rise. Depression in the coke trade has been slightly relieved by the price cuts already announced. Quotations:—Best branch handpicked, 40*s.* to 41*s.*; Barnsley best Silkstone, 40*s.* to 41*s.*; Derbyshire best brights, 38*s.* to 39*s.*; Derbyshire housecoal, 37*s.* to 38*s.*; Derbyshire best large nuts, 34*s.* to 35*s.*; Derbyshire small nuts, 33*s.* to 34*s.*; Yorkshire hards, 35*s.* to 36*s.*; Derbyshire hards, 34*s.* 6*d.* to 35*s.*; rough slacks, 20*s.* to 22*s.*; smalls, 15*s.* to 16*s.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

Middlesbrough, Wednesday.

The Cleveland Iron Trade.—Quietness still characterises business in Cleveland pig-iron, and the usual holidays for race week have checked trade until there is practically nothing doing. A rather better feeling, however, as regards the near future, is noticeable, and hope is expressed that output will increase to some extent now that costs of production are falling. No. 3 G.M.B. continues exceedingly scarce, and can hardly be bought unless equal purchases are made of No. 4 foundry, which is a good deal less scarce. With such proviso, makers will accept 132*s.* 6*d.* for mixed lots. Separately the quotations are 135*s.* for No. 3, and 130*s.* for foundry No. 4. Stocks of the lower qualities are

still large, and producers would be glad to reduce them by sales at 117*s.* 6*d.* for No. 4 forge, and mottled, and 115*s.* for white iron.

Hematite.—Hematite is none too plentiful, but re-commencement of the manufacture of this commodity by the re-lighting of two furnaces at the Normanby Iron-works has improved the situation. Values are stiffening, though purchases of mixed numbers can still be made at 160*s.* for home consumption. Until recently, parcels for shipment abroad were offered freely at 140*s.*, but many makers have advanced their export quotation to the home figure.

Blastfurnaces in Operation.—Of the 72 blastfurnaces built in this district, as yet only 11 have been re-started. Seven of these are producing entirely for use at works, belonging to the owners of the furnaces, two are making Cleveland foundry pig-iron, portion of which is available for sale in the open market, and two are turning out hematite.

Manufactured Iron and Steel.—Little news is ascertainable concerning finished iron and steel. The North Eastern Steelworks, which until recently were closed for a long period, are working through the holiday week, but most other firms have closed their establishments for the usual race holiday. Further reductions in quotations are anticipated. Common iron bars are 16*l.*; marked bars, 20*l.*; steel boiler plates, 21*l.*; steel ship bridge and tank plates, 15*l.*; steel angles and joists, 14*l.* 10*s.*; heavy steel rails, 15*l.*; black sheets, 17*l.* 10*s.*; and corrugated galvanised sheets, 21*l.* 10*s.*

Foreign Ore.—Some little talk of business in ore has been heard, but transactions of any consequence are not likely to occur, until the huge stocks have been much reduced, and arrears of delivery against old contracts have been made.

Coke.—The situation as regards Durham coke is still unsatisfactory, but is improving. Blast furnace kind could be bought at below 40*s.*, but local consumers consider the price should be in the neighbourhood of 30*s.*, which is the figure at which Yorkshire furnace coke is offered. Further substantial drop in Durham kind is confidently expected.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—The depressed state of the Scottish Steel trade shows no signs of easing off, and order books are not filling up at all. The business passing at present is mainly of the necessary type as buyers are holding off and are loth to place fresh orders under the conditions now prevailing. The inquiry generally is a little better, but it is not bringing forth much result, and indeed it is freely accepted that prices will require to be reduced considerably before trade begins to open out. The demand for light material is not very encouraging, but inquiries from abroad for sheets have raised hopes that some fresh business may be booked in the near future. Belgian sheets are being sold very cheap here, and agents have picked up quite a lot of business.

Malleable Iron Trade.—No change can be reported in connection with the malleable iron trade of the west of Scotland, and business is very quiet still. Order books are not heavy, and at times there is little enough doing to keep the workers employed, but this cannotbe wondered at when continental bars are quoted round about half the price of the home bars. Makers have not yet seen their position clear to reduce prices, but to-day's high level cannot be maintained if works are to be kept moving.

Scottish Pig Iron Trade.—The production of Scottish pig iron has not yet commenced and stocks are gradually getting smaller. In the case of foundry iron the position will not improve until some of the furnaces are relighted, which may be very soonnow, but forge iron is also getting scarcer. If fuel would only be reduced to what could be termed a respectable level then most producers would start right away, and with much lower prices, the continental iron would soon be very poorly supported in this country. In the meantime, however, there is quite a big demand for the latter on account of the cheap figure at which it is offered.

Clyde Shipbuilding. — The outlook for shipbuilding on the Clyde is not very promising at the present time, and managements are having rather an anxious time. Messrs. Yarrow and Co. (Limited), who transferred their field of operations from Poplar on the Thames to Scotstoun on the Clyde, in 1906, intimate that they intend closing down their yards in about three months' time. This move is only temporary of course, and is until conditions become more settled all round. The following is a copy of the notice now posted up at the works:—

"Owing to repeated strikes, reduction of output, and demarcation disputes which have taken place in various industries throughout the country, the cost of shipbuilding has become excessive; in addition to which it is impossible to promise date of delivery.

"With the greatest regret we have therefore decided to temporarily close our works, with the exception of our experimental and research department, on or about November 30.

"We shall reopen when conditions enable business to be carried on with some chance of success.

"We give this early notice of our decision so that our employees may have every opportunity of obtaining work elsewhere."

(Signed) "Yarrow and Co., Limited."

In a letter to the press the firm state that they have great faith in the future of the shipbuilding and engineering industries in this country, and they believe that prosperity will return when everyone realises that commercial undertakings can only be carried out with success in accordance with economic laws. As soon as these laws are recognised it will enable them to reopen their works, and, as in the past, take some share in future progress.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—The coal trade is still in an unsatisfactory position. On the one hand, buyers continue to hold off, declaring that prices are not yet at bottom, while colliery owners declare that rather than sell at less than current values, which they state closely approximate the estimated cost of production, they will effect stoppages at the pits as they cannot be expected to sell at a loss. The demand generally is very small, and colliery salesmen are experiencing difficulty in disposing of outputs with the result that the railways are congested with hundreds of loaded wagons awaiting shipment and sale, while collieries are imperilled in respect to regular working by shortages of empties. While some colliery salesmen are in a comparatively comfortable position and refuse to take less than 37*s.* 6*d.* for best Admiralty large, 35*s.* for second Admiralty and best Monmouthshire large, 20*s.* for best steam smalls, 17*s.* for ordinary smalls, 16*s.* for cargo smalls and 25*s.* for throughs, others are prepared to make concessions up to 2*s.* 6*d.* for definite and quick business. Some interesting contract business has been reported during the week, and though the amounts involved are comparatively small, they are significant in view of the hold-off attitude hitherto adopted by buyers. The French State Railways have contracted for 20,000 tons of best Monmouthshire large coal, delivery between now and the middle of October, at 90 francs c.i.f., which at the current rate of exchange is equivalent to about 38*s.* 6*d.*, which represents an f.o.b. price of roughly 30*s.* after allowing for a freight of 8*s.* 6*d.* to the near French ports. Another French railway has placed an order with exporters for 20,000 tons of good steam smalls at 25*s.* c.i.f., delivery over the next two months, while a foreign depot-owning firm has placed a contract for a substantial quantity of Admiralty and Monmouthshire large at 31*s.* f.o.b. delivery up till the end of June next. Despite the apparent inactivity of the coal market, foreign shipments of coal as cargo at 306,000 tons established a record for the current year, and were 45,000 tons in excess of the previous highest weekly export, but 55,000 tons less than the record quantity sent abroad in 1920. Shipments last week were mainly to France, which country took 115,000 tons, Italy 55,000 tons, South America 27,000 tons, Spain 21,000 tons, Portugal 21,000 tons, British coaling depots 35,000 tons and other countries 33,000 tons. Patent fuel exports at 29,000 tons last week have only been exceeded on one previous occasion this year. How great has been the drop in the price of coal this year will be realised when it is mentioned that the average f.o.b. price of coal exported at Cardiff in July was 21*s.* 1*d.* in the case of small, compared with 49*s.* 4*d.* in January, for through 35*s.* 5*d.* compared with 52*s.* 11*d.* and for large 45*s.* 9*d.*, compared with 74*s.* 11*d.* The reduction in respect to small amounts to 28*s.* 3*d.* per ton, for through 17*s.* 6*d* and for large 29*s.* 2*d.*

UNIVERSITY OF BRISTOL.—The prospectus of the Faculty of Engineering of the University of Bristol, for the Session 1921–22, has now been issued. The day classes begin on October 4, 1921. The course of studies include mathematics; applied chemistry; civil; mechanical, mining, electrical and automobile engineering, among other branches.

A METHOD OF CALCULATING THE STRENGTH OF SLABS: ERRATA.—In formula (19) of the above article on page 245 of our last issue, for $\frac{p\,a^2}{26}$, read $\frac{p\,a^2}{28}$. The heading of Table I should read: "Stresses in rectangular slabs supported at all four edges," *not* "fixed at all four edges," as printed.

IMPREGNATION OF MINE TIMBER.—Late in 1915 a series of tests were made in Germany on the value of various methods of impregnating mine timber. It was intended that the timber should be set up under various conditions, and examined at intervals of one year. It was also proposed to analyse the air at the respective spots and take its temperature and moisture. Owing to the war the programme could only partly be carried out. Examinations were actually made in 1916, 1918 and 1921, and the results of the tests so far conducted are explained by O. Dobbelshein in *Glück Auf* of June 25 last. The impregnating materials tested were: basilit applied in concentrations of 1·68 per cent. or 0·77 per cent.; two mercury compounds (organic or silicates) the metal salts Glück Auf, applied in concentration of 6 per cent. and 3 per cent.; and taroil. The impregnation with these materials was effected by the vacuum process. Of the immersion processes only that with mercury sublimate (the cyanising process) proved satisfactory, but the sublimate is very poisonous. Some other processes were rejected as too expensive, and the only ones recommended are the basilit (which prevented all decay even with the diluted solution), the tar oil and the strong solution of metal salts. In some cases impregnation undoubtedly rendered good service. Whether or not it can be recommended on the whole is still considered an open question, and it is doubtful also whether impregnation should be effected on the spot or whether the timber should be bought impregnated.

NOTICE OF MEETING.

THE MIDLAND INSTITUTE OF MINING, CIVIL AND MECHANICAL ENGINEERS.—Thursday, August 25, at 2.15 p.m., Annual General Meeting in the Mappin Hall, Sheffield University, St. George's-square, Sheffield. A paper will be read on "Friction Co-efficient of Minerals," by Mr. Stanley Nettleton. The following papers will be open for discussion: (*a*) "Firedamp Explosions," Professor R. V. Wheeler; (*b*) "Abstract on No. 1 Memorandum of the Miners' Lamp Committee," Professor F. E. Armstrong; (*c*) "Metering of Compressed Air," Mr. John L. Hodgson; (*d*) "Electric Haulage and Elimination of Pit Ponies," Mr. S. Diggle. The discussion will be followed by the reading of a paper on "Low Temperature Carbonisation," by Mr. A. Yeadon.

A DENSE VARIETY OF AMORPHOUS CARBON.—By reducing carbon from compounds which do not contain hydrogen, G. Tammann claims to have obtained varieties of amorphous carbon which are described as both denser and more active than ordinary charcoal or than graphite. The particulars of this work are given in the *Zeitschrift für Anorganische Chemie* 115, pages 141 to 144 and pages 145 to 158.

BLAST FURNACE SLAG AND FIRE-BRICKS.—Last spring the Technical High School at Charlottenburg arranged for a course of college vacation lectures with laboratory practice on the constitution, testing and applications of blast-furnace slag and fire-bricks; the latter course dealt also with the raw materials and with fire-brick manufacture. The course is to be repeated this October, and will occupy a full week. The lecturer is Dr. K. Endell and the lectures are for chemists and metallurgists in practice.

COKING OF SAAR COAL.—According to a communication presented by Baille Batelle to the Paris Académie (*Comptes Rendus*, vol. 172, pages 1580 to 1582), the temperature of the coke ovens for the coal from the Saar basin, now in French occupation, should not at once be allowed to rise high, since the outer layers of coal get much hotter than those in the centre of the charge. He keeps the temperature below 320 deg. C. until heating is fairly uniform throughout; then raising the temperature to 750 deg. and maintaining it at that figure until coking is completed. In a trial of a coke oven of a capacity of 500 kg. the total heating took 50 hours. The coke produced was judged to be comparable with the best coke from the Ruhr basin, while 22 kg. of ammonium sulphate were obtained per ton of coal. The ash content of this coal is 7 per cent.

IRON INSTEAD OF WOOD PROPS FOR MINES.—Since 1916 experiments have been made in some collieries of the Ruhr basin in replacing the wooden props by two-parts posts of channel iron. In *Glück Auf* of June 8 last P. Fink, superintendent of the Colliery Prosper III., writes that his experience with nearly 10,000 iron posts is decidedly favourable. The iron props are used particularly in shales which are apt to cave in. Much of the timber was spoiled and lost in these mines, and when timber became scarce and wages and transport more costly, iron was given a fair trial. The posts were originally made of an upper T iron sliding in a channel iron. Later on both the upper and the lower portions were made of channel iron, the two channels fitting into one another so as to form a rectangle. The upper iron is cut off obliquely at its lower end, and a wooden wedge is driven in between the two irons; by means of short section of a rack fixed to the back of the wedge, an iron strap and a bolt, the two parts are held together while still able to yield to a considerable extent to the pressure of the roof. By loosening the bolt the post can easily be adjusted and be removed when no longer wanted in its original position. Fink shows that he has saved quite a substantial sum by making use of the iron props, which have not to be transported over considerable distances.

OCCLUSION OF WATER BY GAS-MASK CHARCOAL.—Having observed that moist charcoal, stored in an open tube, gave off unusual quantities of steam when heated to several degrees above the boiling point of water, Ben E. Brown, of the University of Kansas (Physical Review, June last, pages 700 to 707) determined the effect of temperature on the amount of water occluded by gas-mask charcoal, which he obtained from the United States Bureau of Mines. The charcoal, 8·5 grammes by weight, was flooded in distilled water and then dried at 101 deg. C. to 104 deg. C., until no more moisture came off. The temperature was raised a few degrees at the time until equilibrium was re-established, and the amount of water expelled was determined. Connection of the bulb with the atmosphere, with the barometer at nominal pressure, 74 cm. of mercury, was maintained through a long capillary tube, 0·75 mm. bore. Finally, the charcoal was baked at 220 deg. for more than half an hour, when most of the water would be expelled, though probably not all of it. In further experiments the pressure was raised to 100 cm. or 150 cm. of mercury. Regular pressure-temperature curves were obtained, not straight but slightly curved upward. The actual pressure to which the water is submitted in the pores is probably very much greater than the equilibrium vapour pressure just outside the pores; this latter pressure corresponded, fairly to the variation of the vapour pressure for solutions, within the temperature range investigated, 95 deg. to 130 deg. About one-third of the total water in the charcoal came off between 112 deg. C. and 114 deg. C.

THE BIRKENHEAD NEW WATER SUPPLY.

SIR ALEXANDER BINNIE, SON AND DEACON, ENGINEERS, WESTMINSTER.

(*For Description, see Page* 286.)

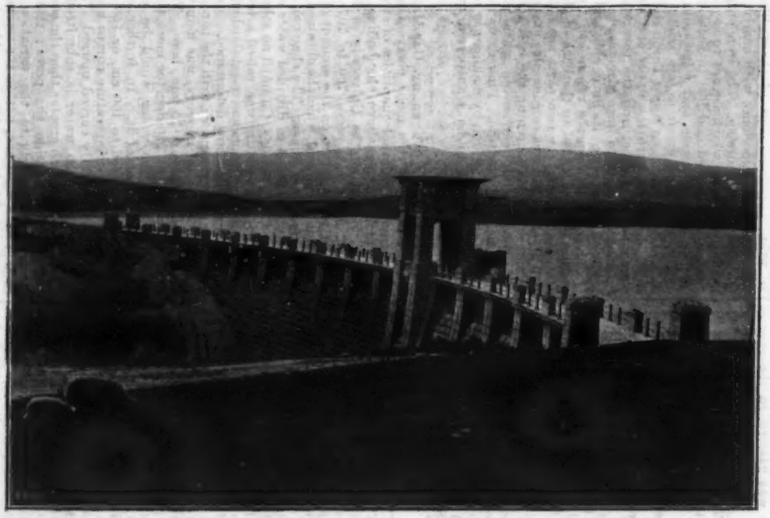


Fig. 1. General View of Alwen Dam.

Fig. 2. Basin and Measuring Weir below the Alwen Dam.

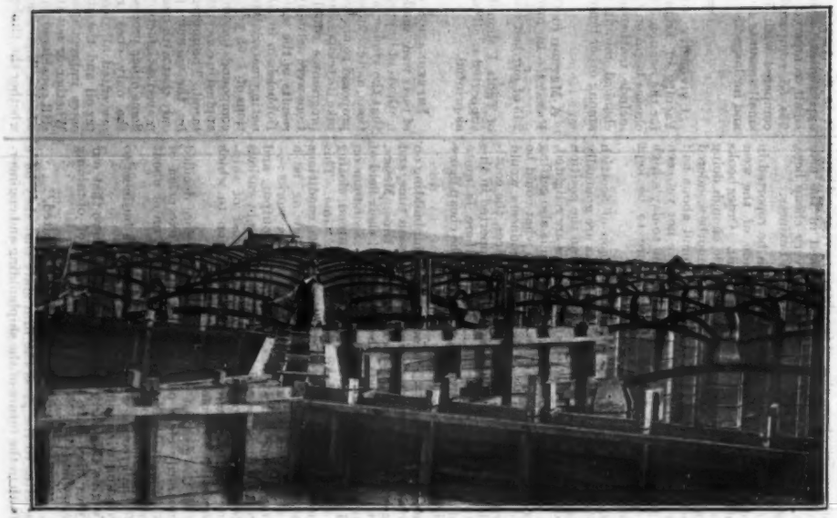


Fig. 3. Crosshill Reservoir, showing Columns and Reinforcement.

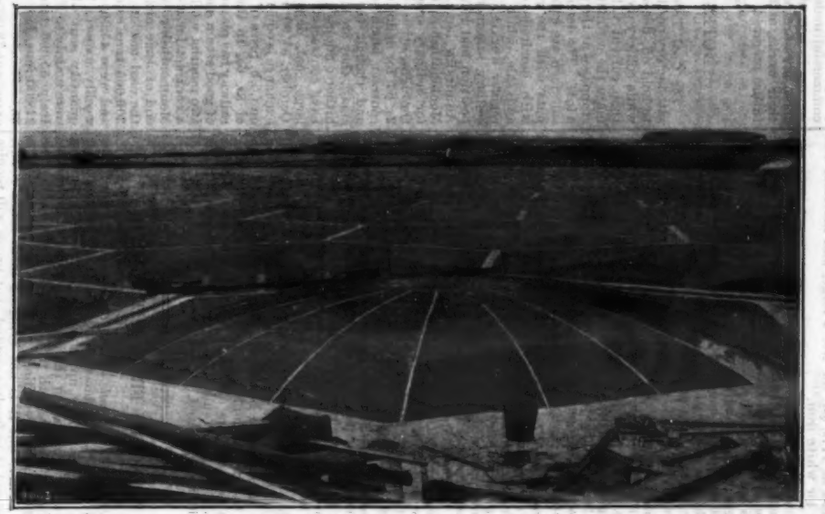


Fig. 4. Crosshill Reservoir, showing Dome and Groins.

THE WORKS OF MESSRS. EDGAR ALLEN AND CO., LTD., SHEFFIELD.

DETAILS OF RAILWAY AND TRAMWAY TRACK SHOP.

(*For Description, see Page 272.*)

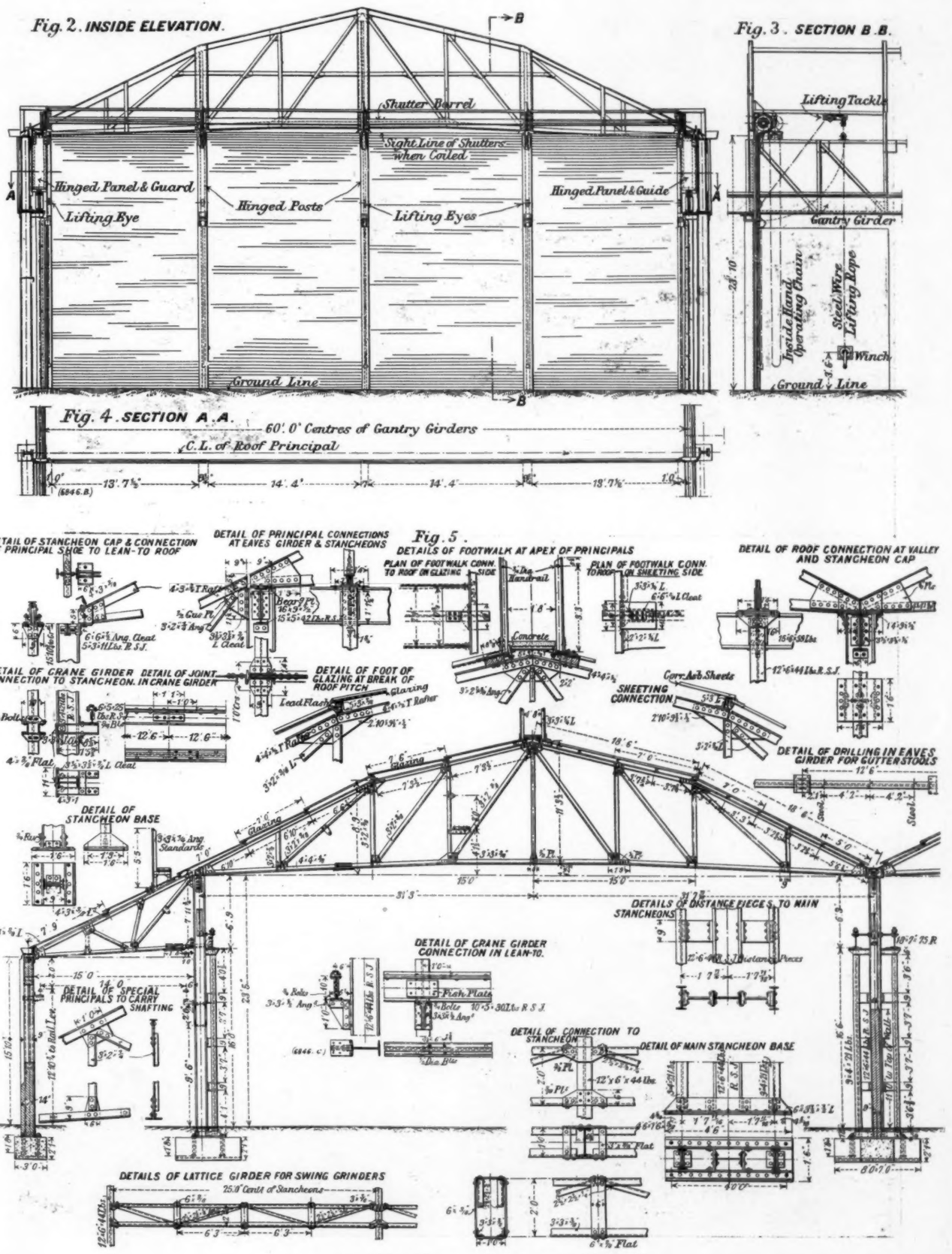


Fig. 2. INSIDE ELEVATION.
Shutter Barrel
Sight Line of Shutters when Coiled
Hinged Panel & Guard
Lifting Eye
Hinged Posts
Lifting Eyes
Hinged Panel & Guide
Ground Line
Fig. 3. SECTION B.B.
Lifting Tackle
Gantry Girder
Inside Hand Operating Chain
Steel Wire Lifting Rope
Winch
Ground Line
Fig. 4. SECTION A.A.
60' 0" Centres of Gantry Girders
C.L. of Roof Principal
Fig. 5.
DETAIL OF STANCHEON CAP & CONNECTION OF PRINCIPAL SHOE TO LEAN-TO ROOF
DETAIL OF PRINCIPAL CONNECTIONS AT EAVES GIRDER & STANCHEONS
DETAILS OF FOOTWALK AT APEX OF PRINCIPALS
PLAN OF FOOTWALK CONN. TO ROOF ON GLAZING SIDE
PLAN OF FOOTWALK CONN. TO ROOF ON SHEETING SIDE
DETAIL OF ROOF CONNECTION AT VALLEY AND STANCHEON CAP
DETAIL OF CRANE GIRDER CONNECTION TO STANCHEON.
DETAIL OF JOINT IN CRANE GIRDER
DETAIL OF FOOT OF GLAZING AT BREAK OF ROOF PITCH
SHEETING CONNECTION
DETAIL OF DRILLING IN EAVES GIRDER FOR GUTTER STOOLS
DETAIL OF STANCHEON BASE
DETAILS OF DISTANCE PIECES TO MAIN STANCHEONS
DETAIL OF CRANE GIRDER CONNECTION IN LEAN-TO.
DETAIL OF SPECIAL PRINCIPALS TO CARRY SHAFTING
DETAIL OF CONNECTION TO STANCHEON
DETAIL OF MAIN STANCHEON BASE
DETAILS OF LATTICE GIRDER FOR SWING GRINDERS

FIG. 5. DETAILS OF RAILWAY AND TRAMWAY SHOP ROOF.

(*To face page 272.*)

THE WORKS OF MESSRS. EDGAR ALLEN AND CO., LTD., SHEFFIELD.

RAILWAY AND TRAMWAY DEPARTMENT.

(*For Description, see Page* 272.)

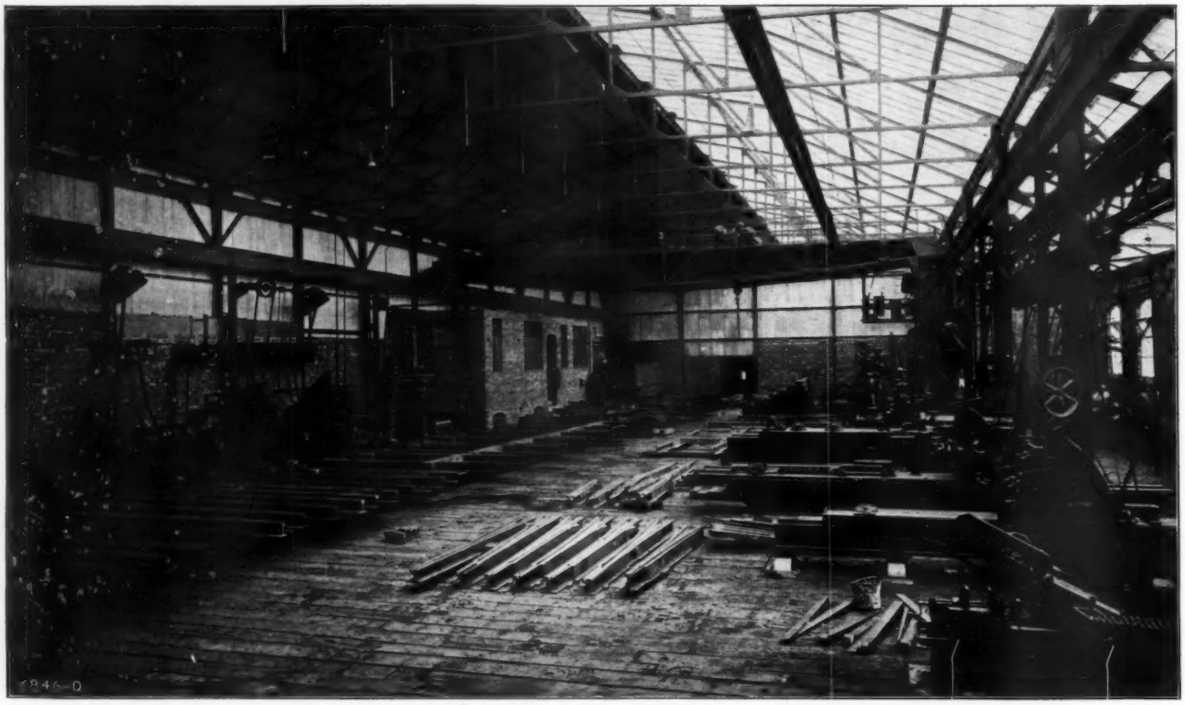


Fig. 6. View in Point Shop.

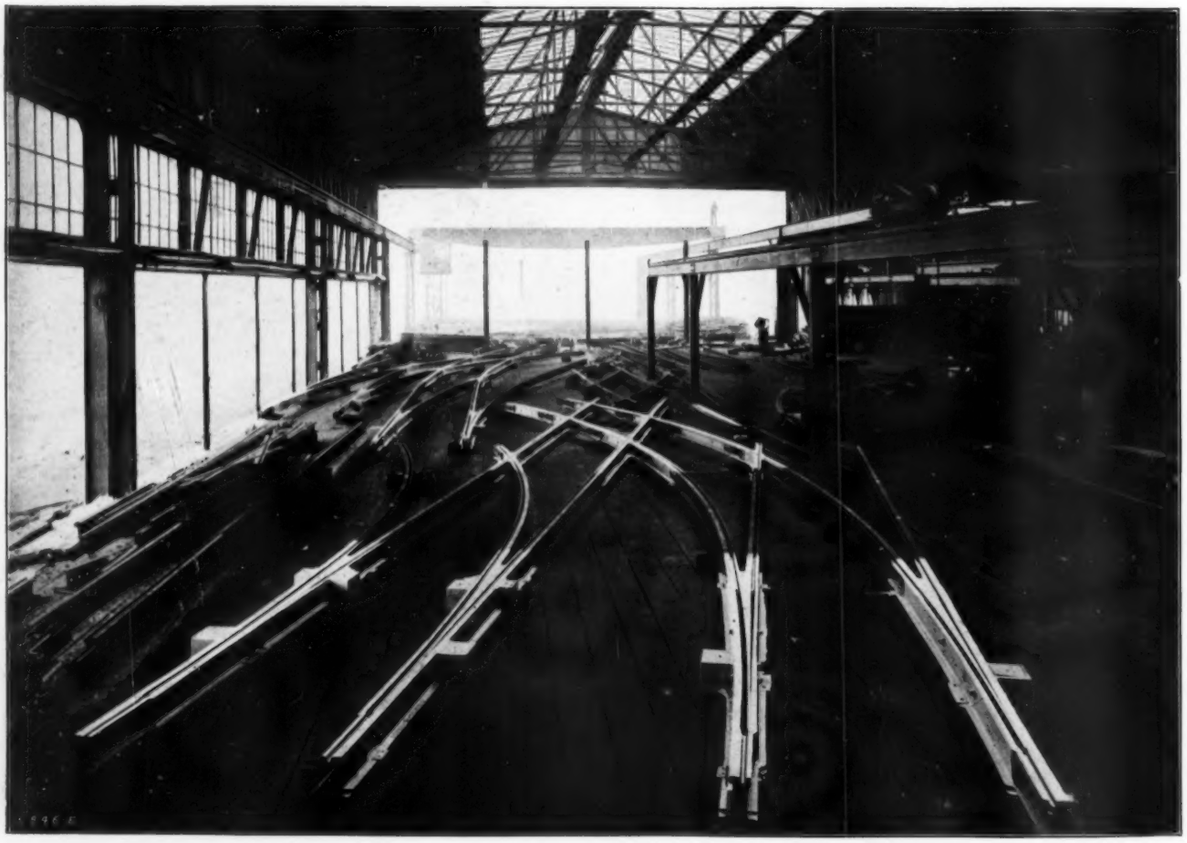


Fig. 7. View in Construction Shop.

THE WORKS OF MESSRS. EDGAR ALLEN AND CO., LTD., SHEFFIELD.

RAILWAY AND TRAMWAY DEPARTMENT.

(*For Description, see Page* 272.)

FIG. 8. COMPLETE TRAMWAY LAY-OUT.

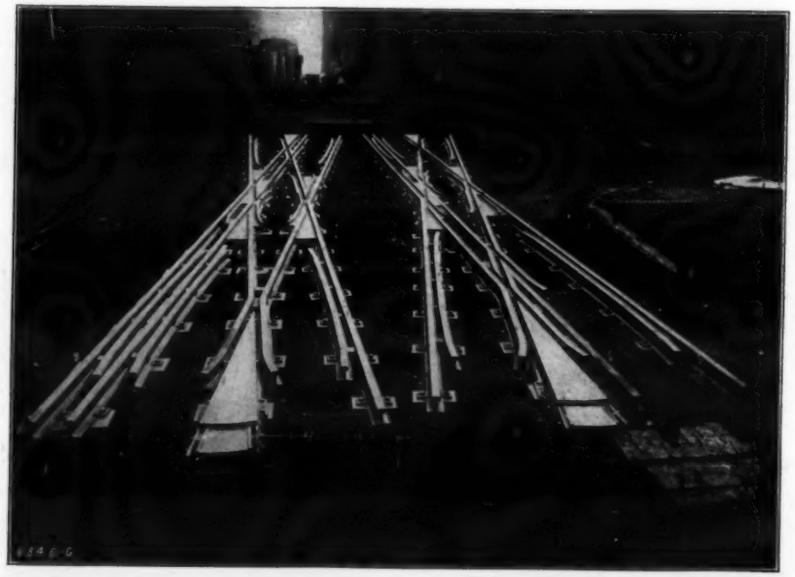


FIG. 9. DIAMOND RAILWAY CROSSINGS FOR DOUBLE GAUGE TRACKS.

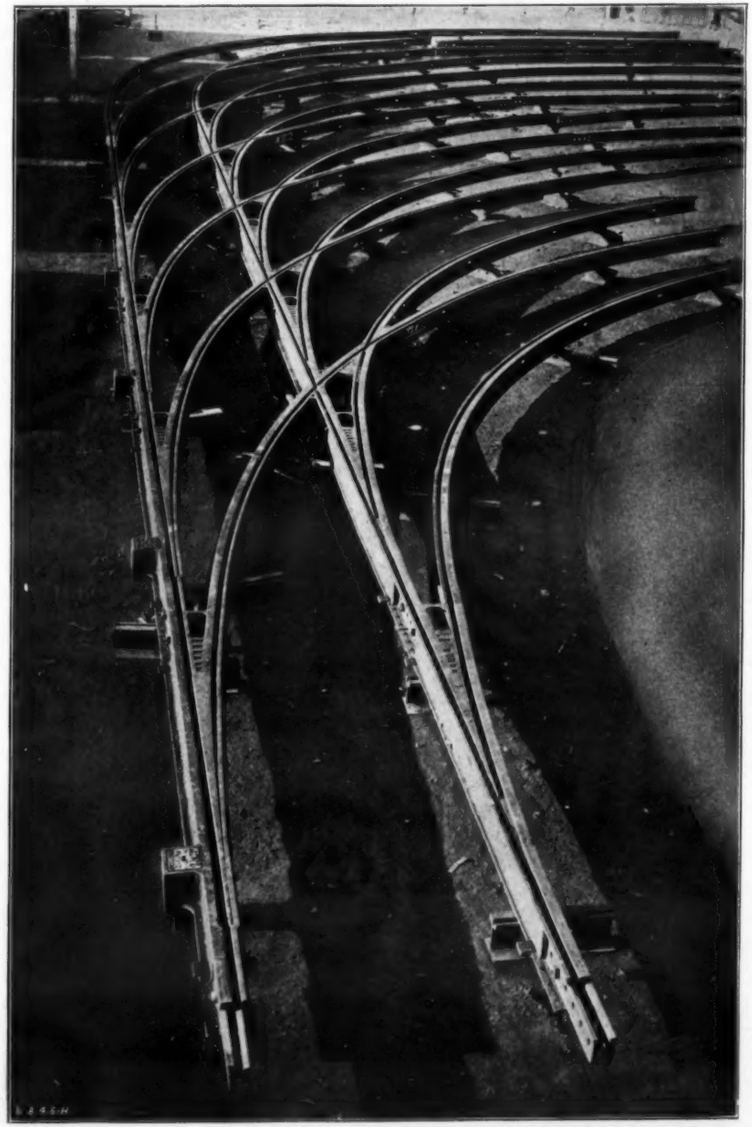


FIG. 10. LAY-OUT FOR CHAPELTOWN CAR DEPOT, LEEDS.

THE RADIOGRAPH OXY-ACETYLENE CUTTING MACHINE.

CONSTRUCTED BY THE DAVIS-BOURNONVILLE COMPANY, ENGINEERS, JERSEY CITY, N.J., U.S.A.

(*For Description, see page 274.*)

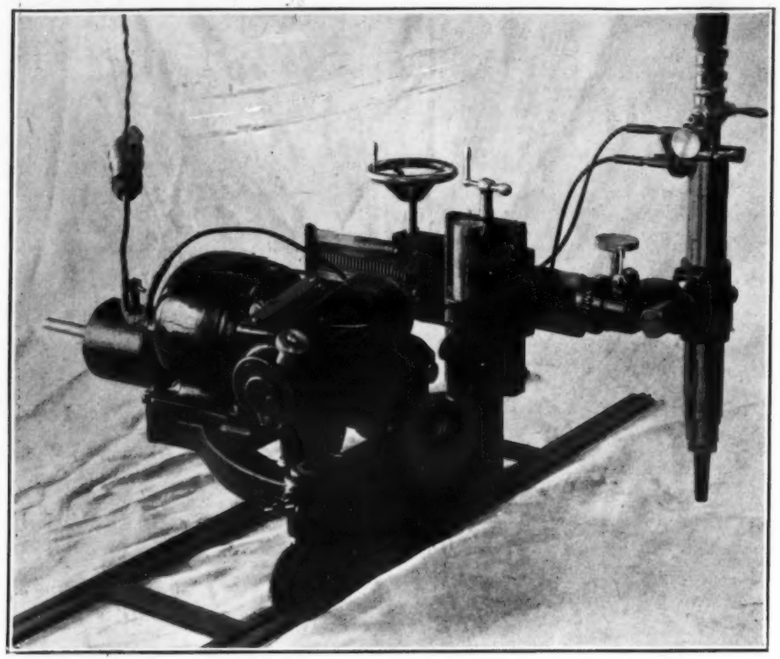


FIG. 1. THE RADIOGRAPH ARRANGED FOR STRAIGHT CUTTING.

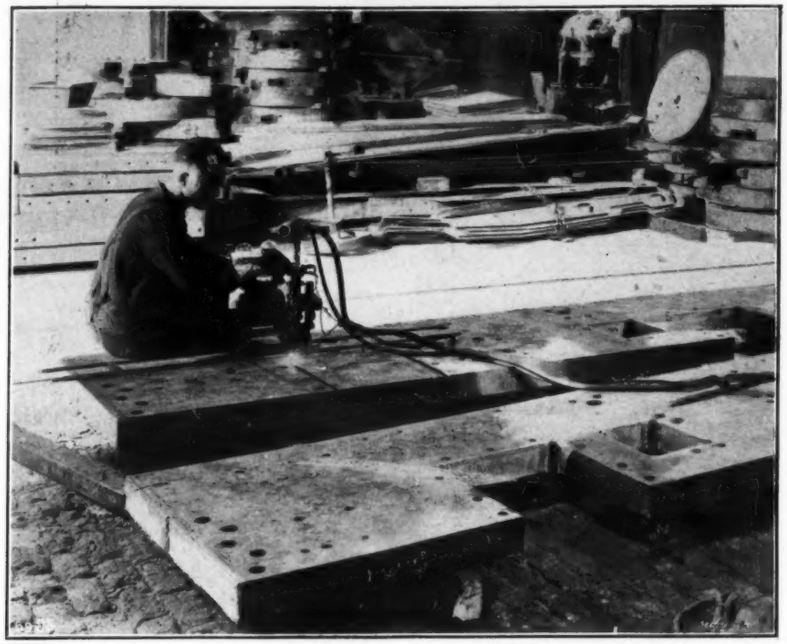


FIG. 2. CUTTING OUT AXLE-BOX GUIDES, &C., IN FRAMES FOR ELECTRIC LOCOMOTIVES.

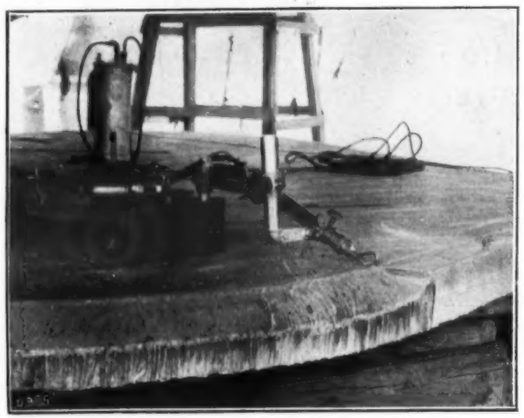


FIG. 3. CUTTING A BEVEL ON A 5-IN. ARMOUR PLATE.

FIG. 4. THE RADIOGRAPH CUTTING STEEL PLATE DISCS.

FIG. 5. DISCS OF 9-IN. STEEL CUT OUT BY RADIOGRAPH.

(*To face page 273.*)

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Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received on the Friday previous to the day of publication.

The charge for advertisements classified under the Headings of Appointments Open, Situations Wanted, Tenders, &c., is four shillings for the first four lines or under, and one shilling per line up to one inch. The line averages seven words. When an advertisement measures an inch or more the charge is 12s. per inch. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

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Thick paper copies	£3 3 0
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Thin paper copies	£3 3 0
Thick paper copies	£3 7 6

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TELEPHONE NUMBERS—3663 and 8598 GERRARD.

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With Three One-Page Plates of the WORKS OF MESSRS. EDGAR ALLEN AND CO., LIMITED, SHEFFIELD, and One One-Page Plate of the RADIOGRAPH OXY-ACETYLENE CUTTING MACHINE.

NOTICES OF MEETINGS.

Notices of Meetings to take place during the present and next week will be found on page 283.

ENGINEERING.

FRIDAY, AUGUST 19, 1921.

THE NEW RAILWAY ERA.

THE influence of the Ministry of Transport is likely to have more lasting effect on the railways of this country than for instance on the Severn Barrage, in which case, saving the waste involved in employing highly paid minds to consider an impracticable project, the interest aroused was so fleeting as to remind one of the Biblical reference to man's precarious hold on life—"a wind that passeth away." In that matter the Ministry went off, so to speak, on a side issue, on the excuse that better communication was required between this country and South Wales. It has, however, on the other hand paid a good deal of attention to the objects for which it was brought into being, the chief of which was the formulation of the Government policy as regards the future of our roads and railways.

Most people will admit that both these are very difficult problems to deal with, and there is no doubt that with regard to roads a great advance has been made in their classification, the taxation of vehicles and so on, though some irritation has been caused. In railway matters, probably one of the most useful pieces of early work of the Ministry was the attention it directed to the glaring delays on the part of traders in releasing wagons, and the reduction of such detention by increasing the demurrage rates. The Ministry, so far as one can gather, was not responsible for the effort to ease the shortage of rolling stock by the construction of locomotives and wagons at Woolwich Arsenal. This seems to have been a scheme evolved by the Prime Minister and the Ministry of Munitions. In passing, it is interesting to note that it is now asserted, without, as far as we can find, official contradiction, that locomotives built there have cost 15,000*l.* each, and that so far two have been sold for 10,000*l.* We were told that there would be a ready sale for these engines, either at home or in the colonies, but somehow the market has vanished, and the wagons are said to find no purchasers at all!

It is characteristic of our present methods of government that after much talk about wanting sufficient time to think the railway problem out, the Minister of Transport should have produced a sketch plan which he subsequently found required considerable alteration, and that in the end the revised scheme was introduced so late that only the most drastic treatment and hurried debates, involving the most unusual step of consideration by two concurrent committees, should have enabled the Government to rush the Bill through the House of Commons in the last hours previous to the so-called date of de-control. In speaking at the close of the debate, Sir Eric Geddes acknowledged that the measure had been considerably improved in its passage through the House. A good many people will doubtless be thinking that it is quite possible that it would have been still further bettered by treatment and consideration more in proportion to the far reaching effects which this novel piece of legislation cannot fail to have.

The measure, as we have previously pointed out, is a very composite one, and covers the grouping of the systems, the compensation of the railways for matters arising out of the War, the control of facilities, rates, &c., and the conditions of service of the staff. In view of this heterogeneous collection it was somewhat disappointing that the Speaker was forced to rule that the proposal to introduce a clause empowering the railways to adopt road transport was inadmissible under the title of the Bill, and would have to form the subject of separate legislation. This proposal, when made, created quite a flutter of excitement. Our views on the subject have been often expressed, but we think the road transport people are rather unnecessarily nervous on the subject. The point they make is that if such powers were granted the railways would run the present road services to death by themselves working temporarily at a loss, and would then put up their rates, to the great injury of trade. In this connection it is interesting to note that the new Clause 39 of the Bill deals with "exceptional rates which are competitive . . . in such a manner as to be detrimental to the public interests," and empowers the Minister to instruct the rates tribunal to consider, and if necessary, vary or cancel such rates. This would seem to cover just what the road transport companies are after, but unfortunately for them the Clause has been limited to coastwise and canal traffic.

The matter may, however, it seems to us, be approached from another direction. One of the corner stones on which the whole Bill is raised is the new tribunal which is intended so to regulate rates as to ensure to the railways, with efficient management, a standard revenue. In more than one place it is stated, as far as we can see without limit of application, that if the Minister is of opinion that exceptional rates are being granted of a character "to jeopardise the realisation of the standard revenue," the matter may be referred by him to the tribunal who may revise or cancel them. The chief argument of the road transport people is, as stated above, that the railways may run services at a loss till they have been driven off the roads. The clauses we refer to should aid to remove any such apprehension. If, on the other hand, the railways can, without jeopardising the standard revenue, still run road services more cheaply than the existing road companies can or care to do, the latter have no reasonable complaint, as they themselves have often taken up the attitude that the public should have the benefit of the cheapest possible service.

The Bill in its passage through the House of Commons underwent too many changes for all to be referred to in a short discussion on general lines. It may be noted that the grouping as at first proposed has undergone considerable modification, the Scotch railways being split up among the English east and west coast groups, instead of being kept in a group by themselves. Reference to a map shows how extraordinarily complicated this grouping is, with interlacing lines reaching far into the territory of other groups. Undoubtedly a vast number of points will arise which will require the most careful consideration of the Amalgamation Tribunal to which the Minister has astutely left the unravelling of many knotty questions. The compensation clauses have also been recast, as have those on exceptional rates. In connection with the rates tribunal the composition of the assisting panels has been revised and elaborated. Originally the Bill provided for two panels, one of twelve railway experts and one of twelve traders, nominated respectively by the Minister after consultation with the Railway Companies' Association, and the President of the Board of Trade. The panels are still two in number, but one consists of thirty-six and the other of twelve persons. The panel of thirty-six is to be made up of twenty-two representatives of trading interests nominated by the President of the Board of Trade, twelve nominated by the Minister of Labour as representative of the interests of labour and of passengers, and two by the Minister of Agriculture and Fisheries in the interests of agriculture and horticulture. The other panel is to consist of eleven railway representatives and one representative of light railways.

In the same way the original provisions regarding the central and national wages boards have become much more specific. Instead of merely stating that these boards should be reconstituted so as to include representatives of the Railway Clerks' Association, as well as the National Union of Railwaymen and the Society of Locomotive Engineers and Firemen, the new clause deals with each board separately. The central board is to be composed of eight railway representatives and eight representatives of employees, of the latter four to be appointed by the National Union, two by the Locomotive Engineers and Firemen and two by the Clerks' Association. The National

Wages Board will be composed of six railway representatives, six representatives of railway employees, each of the three trade unions mentioned previously being represented by two, and four representatives of users, with an independent chairman. The users' representatives are to be rather curiously selected. Two will be representatives of traders, being selected by the Association of British Chambers of Commerce, and the Federation of British Industries, as is natural enough. The other two are to be selected respectively by the Parliamentary Committee of the Trades Union Congress, and by the Co-operative Union. Both these are, of course, party representatives of a definite section of the population. In any broader sense the general public is not represented.

The Bill is admittedly an experiment, and while it is a great deal better than the disastrous uncertainty of the last two years a lengthy period of transition must elapse before it will be possible to see whether it will turn out well or not. We would have liked to see so important a measure receive much greater attention and more mature consideration on the part of the Legislature, and cannot but think that an Act resulting from negotiations in some cases carried on so late that fundamental changes were introduced at the very last moment, will develop before long defects which may greatly add to the complications of the intended reorganisation and regulation.

THE BREAKING POINT.

It is now fairly evident that we cannot indefinitely live on the enthusiasm surrounding the "New Age" which was ushered in by the Armistice. It begins to be clear that, like Adam, we must sweat for our bread. We do not know that labour suffered more from the impossible hopes and beliefs of two years ago than any other class, but it is perhaps slower in learning the lesson of the last six months. One might imagine that it would now be clear to everybody that economic salvation can only lie in genuine hard work and in an attempt to introduce a nearer correspondence between prices and values, between wages and work done; but labour appears yet far from a proper realisation of affairs. There has been plenty of preaching on this subject of late, and although it has had a little effect it is clear that preaching only is not going to lead us out of the wood.

It is a fortunate dispensation of nature that illusion and folly cannot last for ever. If argument will not convince the follower of a mirage, fact ultimately will. If impossible conditions are introduced, industry cannot be carried on. Its complexity and inertia will prevent an immediate stop, but a stop sooner or later there will be. Several of our industries, and notably shipbuilding, are not far from this state now, and unless the conditions are modified a stop is more than possible. In one important instance the stop is definitely coming. This stop has been forced by circumstances, and has nothing to do with any attempt by capital to weaken labour. The fact that Messrs. Yarrow are to close down, while other firms have so far announced no such intention, is in one sense a matter on which the firm is to be congratulated. They have realised that conditions are impossible and have boldly faced the facts without further dependence on conference and consultation, of which there has already been more than enough.

It is probably fair to say that shipbuilding has never been in a worse position than now. The state of the world's trade would be a bad enough condition with which to deal if it stood alone, but when there is added to it such a state of affairs as that created by the ship joiners' strike, the continual minor disputes and the fall in individual output one can well understand a decision that a complete stoppage is the best course. It is very possible that Messrs. Yarrow could have carried on a while longer by paying away their reserves and capital in wages, but proceedings of that kind only tend further to weaken the economic position of the country and would ultimately be worse for labour than a present shut-down. The closing of Messrs. Yarrow's yard is one of the facts which will ultimately convince the labour organisations of this country that we cannot go on as we have been going on.

We have more than once dealt with the effect of the joiners' strike on the shipbuilding industry, and need not now refer further to the paralysis it has caused and the flow of ship repair and completion work to foreign ports. The condition of affairs is too well known to require restatement. It is worth noting, however, that this calamitous strike was assisted and prolonged at the expense of the direct revenue of the country. The uneconomic wages paid in State and rate-assisted housing schemes helped labour in its indefensible prolongation of the ship joiners' strike. The matter may have been difficult or impossible to deal with but it was an illustration of the ramifications of interferences with economic laws.

There is an impression abroad that the general trade of the country shows some slight signs of recovery. If this be so, part of the credit may be given to such assistance towards reduced production costs as industry has received from the fall in wage rates consequent mainly on the fall in the cost of living. Such savings are all to the good, and introduce a little nearer correspondence between money paid and work done, but they touch only the fringe of the problem. It will have been noted that Messrs. Yarrow say nothing about wages in the announcement indicating the close of their yard. It is uncertainty, continual strikes, and slack work which have forced their shut-down, and continuance of these same conditions must lead to further examples of the same thing.

The normal shipyard is not run either as an amusement or as a philanthropic experiment. It is run by its owners as a means of livelihood, and if instead of bringing in an income it absorbs one it will not and cannot be indefinitely carried on. It goes without saying, however, that such valuable properties as the shipyards of the Clyde or elsewhere will not be abandoned without an effort. Messrs. Yarrow make no announcement about their intentions for the future. Probably they could hardly say what their future steps are likely to be. The general possibility is, however, clear enough. A very large proportion of the present trouble is owing to the action of the skilled unions. Unless they are prepared fully to recognise the facts of the situation there must and will be an attempt to eliminate these organizations. The great engineering manufacturers of this country have recognised the engineering unions and worked with them frankly, but if the unions are now going to refuse any effective working with the manufacturers there can be but one way of dealing with the matter. Self-preservation dictates it. Apparently the action of Messrs. Yarrow has brought some realisation to at least one of the unions with the resultant collapse of the joiners' strike. We trust its effect may carry even further. If it does not there only remains a move towards the open shop.

THE BIRKENHEAD NEW WATER SUPPLY.

The Corporation of Birkenhead inaugurated, on Monday, August 15, the new water supply for which it obtained powers in 1907. Many years ago it was recognised that a more reliable source of water supply must be obtained than the wells which had so far served the town's requirements, and negotiations were entered into with the Corporation of Liverpool to enable Birkenhead to participate in the supply drawn from Lake Vyrnwy. The Liverpool County Council, however, eventually rejected the proposal on the grounds that the increasing population of that city would require the whole of the water obtained from that source. Birkenhead had therefore to select a distant catchment area for itself and to devise a scheme for bringing the water to the borough by means of a pipe line. The late Dr. G. F. Deacon recommended the purchase of a portion of the Alwen watershed in mid-Denbighshire, and the original proposal included the construction of three reservoirs at Alwen, Brenig and Glen Alwen in North Wales. That last mentioned, which was intended for the supply of compensation water to riparian owners, did not receive Parliamentary sanction, and, as so far carried out, the scheme includes only the construction of the Alwen reservoir; the Brenig reservoir will be constructed later. The Rivers Alwen and Brenig supplying the reservoirs are tributaries of the Dee, combining to form a single stream which joins the Dee about three miles from the village of Corwen.

The Alwen has a drainage area of 6,313 acres with an average rainfall of 52 in., showing an average yield for the three driest years of 10,800,000 gallons per diem. The powers obtained permitted the use for supply purposes of 7,200,000 gallons, with compensation water placed at 3,600,000 gallons. It may be stated that the Brenig has a drainage area of slightly under 5,000 acres and a rainfall of 49 in. The supply allowable in this case will be 5,200,000 gallons, with 2,600,000 gallons supplied to the river as compensation water. The Alwen reservoir is about 10 miles from Corwen, the nearest village to the site being Cerrig-y-druidion.

The complete portion of the scheme now inaugurated involves several interesting features, including the Alwen Dam, an aqueduct under the Dee, and a service reservoir at Cross Hill, near Barnston, about 3½ miles from Birkenhead. The total length of the aqueduct from the Alwen Dam to the service reservoir at Birkenhead is about 42 miles. The consulting engineers for the work were Sir Alexander Binnie, Son and Deacon, of Westminster, to whom we are indebted for the following particulars of the undertaking. On page 284, in Figs. 1 to 4 and on page 287, in Figs. 5 and 6, we give the views of some of the interesting features of the work.

The Alwen reservoir is formed by a dam approximately 400 ft. in length and 97 ft. 6 in. in height, water being impounded to a depth, at the dam, of 90 ft. The reservoir has a length of over 3 miles and a water area of 365 acres; the quantity of water impounded amounts to over 3,000,000,000 gallons. The dam is of concrete masonry. It is built to gravity section, but is actually arched in plan, being curved to a radius of 500 ft. This is well seen in Fig. 1, page 284. The foundations were carried down to a maximum depth of 55 ft. The concrete used in construction amounted to about 37,000 cub. yards, the centre being mass concrete with plums of local stone. Up-stream the dam is faced with smooth concrete blocks, while on the down-stream side it is finished with blocks moulded to represent rough dressed rock. The effect of this work is very satisfactory. The blocks used weighed from 1 ton to 2 tons. They were moulded on a vibrating table and the concrete employed was 5 : 1. The crest level is 1,190 ft. above O.D. The crest is divided into a number of bays by masonry piers which carry a roadway 10 ft. in width. Eight of these bays are used for the overflow sill, which thus has an aggregate length of 160 ft. This is arranged on the west of the dam on which side also is a flood-water channel leading to a basin with measuring weir below the dam, at which point the compensation water supplied is checked. By means of valves the level in this basin is kept constant when no flood is passing, insuring a constant head over two orifices through which the water passes to the river. The basin and weir below the dam are illustrated in Fig. 2, page 284.

The dam has a valve tower in which is a large standpipe with valves controlling the draw-off at three different levels. A scour pipe is also provided. In the dam the valve tower consists of a 12-ft. shaft, connecting at the bottom with a 12-ft. tunnel. At its lower end the stand pipe is carried along the tunnel terminating in a valve chamber, in which are placed turbines and electrical equipment employed to generate electricity by means of the compensation water passed down. The site of the reservoir was cleared of over 1,000,000 cub. yards of peat, and a marginal wall has been constructed to prevent trouble from the surrounding peat and earth. The water is normally strongly coloured, but is successfully treated before passing to the aqueduct, in Bell mechanical filters. The filter-house is situated a short distance below the dam, and contains 10 batteries each of five filters. The

filter machinery is driven electrically by power generated by the turbines at the dam.

The aqueduct to Birkenhead consists of pipes varying between 36 in. and 19 in. in diameter. As already stated, the distance is about 42 miles. There are four short tunnels in this distance, one of 170 yards, one of 350 yards, a third 250 yards in length and a fourth 175 yards long. With the object of reducing the pressure on the pipes two balancing tanks are provided.

The tunnel under the Dee is 759 ft. in length, and was driven for its whole length through fine water-bearing sand. Its construction was very fully described in a paper read in February last by Mr. R. F. Baker, M.Inst.C.E., who acted as resident engineer on the work, before the Liverpool Engineering Society. We cannot do better than draw on this account of the undertaking for the details which limitations of space will allow us to give. The tunnel is 8 ft. in diameter and connects two shafts of 13 ft. internal diameter, one on each side of the river, that on the English side being 69 ft. deep and that on the Welsh being just under 61 ft. deep. The tunnel slopes on 1 in 107 from the Welsh to the English side. It is intended to accommodate two pipes, but at present only one is installed.

The shafts were sunk by grab, the whole of the kentledge being applied at the top. By pumping out the water which was met with within a few feet of the ground level, it was possible to loosen the soil sufficiently to bring up a full grab on each occasion. The last few feet were done under compressed air by hand excavation. One shaft was done at a time to save the cost of two sets of air locks, and the tunnel was subsequently driven across the river from the Welsh to the English side. The weight of the shaft lining, kentledge, &c., amounted to about 180 tons. When sinking under compressed air this load was not sufficient to cause the shaft to drop when full air pressure was on, and in consequence excavation proceeded in the centre of the bottom, leaving a small bench round the edge. During meal times, &c., the air pressure was then relieved to the extent of 6 lb. or 7 lb. and the shaft sank about 18 in. in 10 minutes. The maximum pressure used on the English shaft was 23 lb. The bottoms of the shafts are sealed with concrete.

In driving the tunnel proper the pressure had to be regulated according to the tide. The rise and fall of the Dee at this point is about 12 ft., with a "bore" at spring tides. The pressure was regulated in accordance with a tide gauge. When the tunnel was started at a little distance from the actual river channel there was a time lag in the tidal effect upon the pressures required; as the work proceeded this decreased and ceased altogether when passing under the channel. The shield adopted was of the hooded type, and the work was carried out on the clay pocket method. Only the four bottom rams were used in pushing, in order to obviate all risk of diving. The shield showed a tendency at one time to roll; this was corrected by attaching a plough to the cutting edge.

The tunnel lining consists of 1 ft. 8 in. rings made up of seven segments and a key-piece. For several weeks it was driven at a rate of 55 ft. per week, until a blow occurred on February 10, 1920. The river channel is at its deepest point 8 ft. 6 in. below ordnance datum, and the top of the tunnel is about 12 ft. below that. The blow did not occur, however, at the deepest part of the channel. A crater was formed, 12 ft. in diameter and 4 ft. 6 in. deep, which had to be filled with clay. The accident was fortunately not attended by serious results to the men on the work, though one man was carried some distance by the rush of air and was bruised to some extent. The work of filling the crater occupied a week, and progress afterwards was a good deal slower.

The pressure used seldom exceeded 20 lb., and no cases of compressed air sickness occurred. A medical air lock was provided, but did not have to be brought into use. The cost of the work amounted to 36,000*l.*, or about twice the amount at pre-war costs.

The Cross Hill reservoir is a particularly interesting piece of work. It has an area of 3·6 acres, 1 ft. in depth equalling the storage of 1,000,000 gallons, the total available depth being 28 ft. The reservoir is covered and is of composite brick, concrete and earth construction. It is designed so that the thrust when full is taken by a surrounding earth embankment, but when empty the pressure of the latter is taken by a series of horizontal brick arches. In plan the reservoir is hexagonal, each side being made up of eight horizontal arches of 30 ft. span and a radius of 27 ft. 6¼ in., with smaller spans at the angle points where two sides meet. At the springing of these horizontal arches there is in each case a vertical steel plate girder, 4 ft. over flanges by over 30 ft. in height. The bases of these vertical girders are embedded in concrete. The upper ends are tied to the interior structure of the tank as will be presently described. The girders are cased in concrete and special moulded blocks which form the springers for the horizontal arches built of brindle brick. The latter work is 14 in. thick to 11 ft. 3 in. above the floor, and 9 in. thick above. It is backed by concrete, 12 in. to 18 in. thick, at the arch centre and 5 ft. thick at the haunches, where it encloses the plate girders. A layer of asphalt, ¾ in. thick, is laid between the concrete and brickwork. The earth bank outside is trimmed to a 2½ : 1 slope, the walls being 21 ft. thick at the top.

The reservoir is roofed in by 217 domes, supported by the side walls and 432 concrete island pillars. The majority of the domes are thus carried on groins connecting six pillars, the plan of each unit being a regular hexagon. The pillars are of moulded hexagonal concrete blocks, 18 in. deep, chamfered top and bottom. A 6-in. hole is cored in the centre, and this was filled with cement mortar. At the top a steel gusset plate is fixed, and to this gusset are attached the ends of the joists forming the reinforcement of the connecting groins. At the outside ring the other ends of this reinforcement are attracted to the steel vertical girders, thus

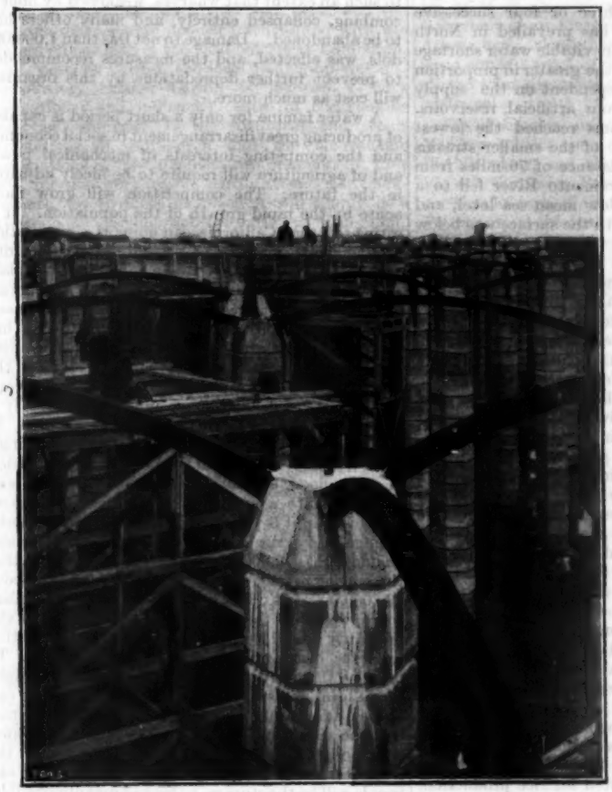


Fig. 5.—Crosshill Reservoir showing Groins and Columns to carry Roof Domes.

Fig. 6.—Interior of Crosshill Reservoir.

tying the whole structure right across the reservoir. The groin reinforcement is 3 in. by 11 lb. steel joist, and the groins themselves in which it is embedded are 14 in. wide and project 14 in. below the dome, and are arched on the underside to a radius of 20 ft. 4 in. These groins were moulded in place. The groins and the reinforcement will be recognised in Figs. 3 and 4, page 284, and 5 and 6, page 287, which give various views of this reservoir during construction.

The domes have a span between opposing parallel groins of 30 ft. They have a minimum thickness of 6 in. at the crown, increasing to 13 in. at the centre of the groins. The intrados is struck to a curve varying from 50 ft. radius at the centre to 17 ft. radius at the springing. Double shuttering was not required for this work. Some elaborate tests were carried out on a section of a dome, in the course of the work, with both symmetrical and unsymmetrical loading, the latter including a test load on one-half of the span of 12 tons of bricks, which the section stood with only ¼ in. deflection and no sign of failure. The centering adopted consisted of triangular scaffolds mounted on wheels. Six scaffolds were placed together between the pillars and on the top was placed the dome centreing, consisting of 18 dome sections and a keypiece. This centering proved very portable and was quickly moved and re-set as the progress of the work required.

The floor of the reservoir is mostly 12 in. thick, on hard sand. In places marl was met with, and this was removed and the concrete carried down to sand, so that the floor thickness is not uniform. The pillars are carried on footings 2 ft. thick, these footings being hexagonal in plan with 8 ft. sides. The side wall foundations are carried 2 ft. 3 in. below the floor level except at the vertical steel girders where it is taken down to a depth of 3 ft. 2 in. The floor is covered with asphalt ¾ in. thick. Seyssel asphalt was used spread in two layers, ¾ in. thick, this quality being hard enough not to spread under the load of the pillars, &c.

An inspection shaft of brickwork 9 ft. in internal diameter, is placed in the centre of the reservoir. The inlet well is dry and access can be had to the valves. The main entering it is 25 in. in diameter, and is provided with a reflux valve. The outlet well is similar but is a wet well, the level of water being that of the reservoir, and the pipe from the latter close to the floor. This outlet pipe is provided with a valve so that the well can be isolated. The pipe leaving the well is 28 in. in diameter, and has an automatic emergency valve to shut it in case of a burst main. The Cross Hill tank is stated to be one of the cheapest covered reservoirs constructed, running out at 2,800*l.* per 1,000,000 gallons, which compares with 5,000*l.* for several reservoirs constructed for London works.

The total cost of the scheme as originally mooted in 1907 was estimated at 738,000*l.*, of which 590,000*l.* was allotted to works construction and the remainder to easements. It became necessary to revise the estimates in 1914, since certain engineering difficulties had been encountered, mainly in connection with the removal of peat from the site, and also owing to increased costs of labour and materials. Authority was then obtained for the raising of a loan of 1,000,000*l.* During the war the works were temporarily suspended and on resumption after its conclusion prices had increased to such an extent that the original estimate was raised to 1,332,000*l.* This sum has, however, now proved to be inadequate, as about 1,250,000*l.* has already been expended, and the balance will not suffice for the completion of the scheme sanctioned, which includes, as already stated, the construction of the Brenig reservoir. The town will, however, save a sum of 44,000*l.* annually now expended on pumping, which will not be necessary with the new supply. On Monday, the Mayor, Mr. Luke Lees, said that if the scheme had been postponed till the present time other financial obligations would have probably made it impossible.

The contracts for the Alwen Dam and reservoir, the Cross Hill Tank and part of the pipe line were in the hands of Sir Robert McAlpine and Sons, 50, Pall Mall, S.W. 1, while the remainder of the aqueduct with the Dee tunnel were entrusted to Messrs. John Cochrane and Sons, Limited.

THE ECONOMIC EFFECTS OF DEFICIENT PRECIPITATION.

The reclamation of arid lands by the Federal Government of the United States has proceeded steadily since the beginning of the century. Previous to the war, a million and a half of acres could receive irrigation water, and this area has been greatly increased since by additions to the canal system. The growth of new communities accustomed to the convenience and certainty of a water supply at all times and of the quantity needed, has led to an ever-increasing demand, that has apparently justified further expenditure in conserving and distributing the relatively heavy precipitation of the mountain regions. But recent experiences in California have shown that this extension cannot go on indefinitely. It is limited by the minimum rainfall in a season, for when abnormally light precipitation occurs for three or four successive years, and this deficiency has prevailed in North and Central California, the inevitable water shortage entails loss to an extent all the greater in proportion to the numbers who are dependent on the supply brought to their farms from artificial reservoirs. In 1920, Californian streams reached the lowest stages on record, and some of the smaller streams dried up entirely. At a distance of 70 miles from the Golden Gate, the Sacramento River fell to a point more than a foot below mean sea level, and even 90 miles from the mouth the surface was below this datum.

The consequence of this abnormal shortage can be easily traced. San Francisco Bay is a drowned or submerged valley, being originally the lower reaches of the Sacramento-San Joaquin Rivers, containing now saline waters, while the water in the rivers is fresh. When, as in the summer of 1920, the stages of the fresh-water streams fall below that of the level of the Bay, the stream flow in the lower portion of the rivers is actually reversed, the saline water encroaching upon the rich agricultural lands, which in the past have been irrigated by seepage and the pumping of fresh water from the streams. As a rule the vegetable crops of this favoured delta region are very heavy, but they were much reduced in quantity, the dairy industry was driven to other regions, and the infiltration of salt water through seepage threatened permanent infertility. For domestic use, and for manufactories requiring fresh water, the only supply was by means of barges transporting the water across the bay. Residents were placed on a strict water ration. Further up the river, at Antioch, pipes and boilers in homes and factories were eroded and later fell to pieces.

The rice growers were among the greatest losers. This is a comparatively new industry, but the rich alluvial flood plain of the Sacramento River has been found to be well adapted for rice production, and the value of the crop is placed at 62,000,000 dols. The quantity of water used is very large, amounting to 60 in. or even 120 in. The fields are flooded artificially during the growing season, and abundant water is needed until about September 15. The rice planters, after the experience of previous years, voluntarily reduced the area under cultivation by 50,000 acres, and made their water demands as small as possible. The landowners of the San Francisco Bay region, however, conscious of their own inconveniences and material losses, looking for compensation, sought an injunction in the law courts to prevent the rice growers taking water from the Sacramento River. The landowners contend that the diminished supply was due to excessive pumping for water for rice irrigation up stream. The rice growers maintain that the decreased flow is due to the deficient precipitation, which had depleted the mountain reservoirs and lowered the ground water level to abnormally low stands. The suit is still proceeding and litigation will go on for years, but it is clear that there is not enough water to go round, and the withdrawal of water from other watersheds will injuriously effect those districts.

Engineers have also their grievance. Hydro-electricity is the principal source of mechanical power in California, depending for its ultimate source on storage reservoirs. As the supply of stored water became deficient, resort was had to steam plants for generating electricity. But oil fuel was dear, and labour charges high, compelling the power companies to raise rates by 15 per cent. As a consequence rents were increased, transport was made expensive, street car companies reduced facilities, and compulsion was even brought to bear on the advertising community, and the exhibition of electric signs was restricted to three nights a week.

A curious result was the activity of the "ship-worm," the teredo. This marine organism survives only in water having a salt content between 0·5 per cent. and 4 per cent. By the encroachment of salt water, a suitable habitat was provided for this worm, far from the sea, and as no protection to structures had been provided against such a pest, it proved itself a destructive force of great economic consequence. It burrowed into wooden structures to such an extent that wharves, weakened by honey-combing, collapsed entirely, and many others had to be abandoned. Damage to not less than 1,000,000 dols. was effected, and the measures recommended to prevent further depredations by this organism will cost as much more.

A water famine for only a short period is capable of producing great disarrangement in social economy, and the competing interests of mechanical power and of agriculture will require to be nicely adjusted in the future. The competition will grow more acute by the rapid growth of the population. It is estimated that California can support a population of 30,000,000, if water be properly stored and distributed. The point is that we have to contemplate a new limit to continual expansion, for the actual amount of precipitation cannot be increased by any precautions, and further it is not impossible but that the spread of agriculture will have the effect of causing a more uniform run-off, so that the collection of large quantities in storage reservoirs will be attended with increasing difficulties. It is proposed that the entire district affected be organised by the State Legislature into a single State conservation and flood control district, merging flood control, reclamation, drainage and irrigation into a single unified project. To carry out this plan it is proposed to construct one gigantic storage and irrigation project that would reclaim an additional 12,000,000 acres. It is estimated that the scheme in its entirety would cost a sum of about 700,000,000 dols., but would add billions of dollars to the wealth of the State. It would seem that the first duty would be to make provision for existing interests, both agricultural and manufacturing. To increase the competitors for a limited supply might easily bring disaster in its wake. The question can only be adequately discussed by experts on the spot, but the comment of the *San Francisco Chronicle* is undoubtedly sound. "Rain or shine, for the next decade the most important matter before our people will be the storage, so far as humanly possible, of every drop of water which falls on the State, and its utilisation for irrigation and the development of power."

THE EDINBURGH MEETING OF THE BRITISH ASSOCIATION.

Thirty years will have elapsed since Edinburgh last entertained the British Association, when Sir T. Edward Thorpe opens the 89th annual meeting, on Wednesday, September 7. The previous visits to the capital of Scotland had followed one another at shorter intervals. In 1834, Sir T. M. Brisbane had presided over the first Edinburgh meeting of 1,298 members. The attendances at the first meetings of the Association are a little uncertain: 353 members had attended the inaugural meeting at York in 1831, under the presidency of the Earl of Fitzwilliam; how many went to Oxford in 1832 is not recorded, and about 900 assembled at Cambridge in 1833. When Sir David Brewster presided at Edinburgh in 1850, 1,241 members attended. The president of the next Edinburgh meeting—that of 1871—was Sir William Thomson (Lord Kelvin). The attendance on this occasion did not quite reach that of the previous year at Liverpool, under Professor Huxley, when it was 2,878, and that had been exceeded by the Newcastle meeting of 1863, under Sir William G. Armstrong. At the fourth Edinburgh meeting a great geologist, Sir Archibald

Geikie, was the president, and 2,070 members attended. The Manchester meeting of 1887 had meanwhile, thanks largely to the personal influence of its president, Sir Henry Roscoe, eclipsed previous records by its attendance figure of 3,838 members. That figure was again exceeded in Australia in 1914, where 5,044 members entered their names. But that meeting was a Continental gathering beginning in Western Australia and ending in Queensland in the North East, and can not very well be compared with visits to home cities and towns.

A large attendance is perhaps hardly to be expected for Edinburgh this year. The times are not propitious, especially as regards chemists and other visitors from the Continent, who swelled the ranks at Manchester; Sir Edward Thorpe is a chemist, like Sir Henry Roscoe. Yet nearly a thousand members had notified the London office of their intention of going to Edinburgh up till last week, and the London officers were not then acquainted with the names on the lists of the local officers at Edinburgh. Last year, at Cardiff, the local joining-up was disappointing, though Cardiff is likewise a busy educational and industrial centre of considerable historical interest. If the historical and scenic attractions of Edinburgh and the far-reaching associations of its University are pre-eminent, they will, for that very reason, hardly attract many newcomers, for to most members it will simply be a question of paying another visit to Edinburgh, though not many perhaps will be able to speak of the pleasant meeting held during the first August week of 1892.

That meeting, like its predecessors, was a full week's meeting, Wednesday to Wednesday, and the coming meeting will also last a week, for the first time since the beginning of the war. Those who had been looking forward to a comparatively easy time may be a little disappointed, however, when they study the programme. The full week includes a Sunday, which does not figure on the sectional agenda at all. The first Wednesday is free for the ordinary members, except for those on committees, till 8.30 p.m., when the Presidential address will be delivered, and most of the Sections hope to finish their proceedings by the Tuesday, September 13, so that the other days of the week appear only once on the programmes. Members of Section G, in particular, however, should not leave before the second Wednesday, September 14, when the report of the Committee on complex stress and other important papers will be discussed. The concluding meeting will be held at noon on that Wednesday. There is one clear evening this year, the Monday, the others being taken up by a Reception by the Lord Provost (on Thursday), and by discourses, while the Saturday is, as usual, left for general excursions. But most of the Sections will be very busy; several of them will even sit in the afternoons, which other Sections leave free for visits to works and institutions, and Section A, while hoping to conclude its transactions before the Wednesday, will not only hold afternoon sessions, but revert to its old policy—forced upon it—of subdividing into departments.

In his presidential address, which is to be delivered on the Friday of the week, to Section A, Mathematical and Physical Science, Professor O. W. Richardson, of King's College, will deal with Problems of Physics, including, we may anticipate, the emission of corpuscles, one of his own particular studies. The address is to be followed by a joint discussion with Section B, Chemistry, on the Structure of the Molecule, to be held in the rooms of Section B. Thursday has a long programme. There are papers by Professor J. C. McLennan, of Toronto, on Radiation and Absorption by Atoms with Modified Systems of Extra-nuclear Electrons, and by Professor R. W. Wood, of Baltimore, on Spectra of Hydrogen from Long Vacuum Tubes and on the Time Interval between the Absorption and Emission of Light in Cases of Fluorescence, to be followed by a description, by Dr. Crichton Mitchell, of the Geophysical Observatory in the Shetlands. The Section will then subdivide into a department for Physics and Mathematics (papers by Professor E. T. Whitaker, title not fixed; by Mr. A. A. Campbell Swinton, on Reception of Wireless Waves on a Shielded Frame Aerial; by the Duc De Broglie; and by Professor H. Briggs, on Prehensibility, a Factor in Gaseous Adsorption); and a department for cosmical Physics in which Dr. Carle Salter will discuss the Drought in England of Summer 1921; Captain C. K. M. Douglas will speak on the (Meteorological) Work of Professor Bjerknes, of Bergen; the Report of the Seismological Committee will be presented, and Dr. M. Jeffreys will also make a contribution—all these papers are down for the Thursday morning. In the afternoon, Mr. J. J. Dowling will demonstrate the use of a Recording Ultramicrometer. This is an oscillating valve, with the aid of which a variation in gravity due to a height difference of 1 m. can be detected; and Mr. W. L. Balls will describe a Simple Harmonic Analyser-Periodoscope, which, with the aid of equidistant strings, analyses a curve, a templet of which has been prepared. Dr. Dawson Turner and Mr. D. M. R. Crombie will further demonstrate the Behaviour of an Electrified Pith Ball in an Ionised Atmosphere—altogether for one day 15 communications out of a total of 26, crediting Section A with all the joint discussions in which the Section is to participate.

The discussion on the Quantum Theory, on Monday, is to be opened by Mr. C. G. Darwin, Dr. J. W. Nicholson, and others. In the department of Physics, Professor Barkla will subsequently speak on the Energy of X-Radiations, and Dr. Hans Pettersson on Internal Movements in the Sea, while in the Mathematical department, Mr. J. Cullen and Dr. F. E. Hackett will read papers, the latter on a relativity problem. Professor A. S. Eddington will lecture on Einstein's Theory of Relativity in the afternoon. On Tuesday, the Age of the Earth is to be discussed in a joint meeting with geologists, zoologists, and botanists (Sections C, D, K); Lord Rayleigh will open the proceedings and Professors W. J. Sollas, Eddington, J. W. Gregory and F. Lindemann are to follow. Professor R. A. Sampson is then to describe the Microchronograph, and the Rev. A. L. Cortie, S.J., will present a paper on the Magnetic Storms of the Present Solar Cycle.

Section B, Chemistry will be less overburdened with papers. The keynote will be struck on Thursday by Dr. M. O. Forster in his presidential address on the Laboratory of the Living Organism. Professor R. Robinson is to follow him with a paper on the Genesis of Plant Pigments and Related Substances, and the joint discussions with Section I, Physiology on Biochemistry, as well as the papers by Professor E. C. C. Baly on the Synthesis of Formaldehyde and Carbohydrates from Carbon Dioxide and Water, and by Professor F. M. Jaeger, on Simple Organic Acids by Ultraviolet Radiations, will carry the subject further and into the domain of photochemistry. These papers, as well as one by Professor G. Barger on Microanalysis of Compounds of Carbon, Hydrogen and Nitrogen, and the Reports of Research Committees are to be presented on the Monday. The Friday will be devoted to the joint discussion with Section A on the Structure of the Molecule, which is to be introduced by Dr. Irving Langmuir, of Schenectady, and in which chemists (Professor Smithells and Dr. Partington), as well as physicists (Professors A. O. Rankine, W. L. Bragg and S. H. C. Briggs) have promised to take part. The discussion is to be preceded by a paper by Professor H. E. Fier on the Modern Dyestuff Industry. Other papers of theoretical and technical interest are announced for Tuesday, by Professor F. M. Jaeger on Measurements of Surface Tension over a Wide Range of Temperature, by Mr. Cosmo Johns on Surface Tension of Liquid Steel, and by Professor Cecil H. Desch on Surface Tension and the Solidification of Metals. Dr. J. Owens has also promised a further paper on Suspended Impurities in City Atmospheres. Visits to various laboratories, breweries, the North British Rubber Works at Castle Hill, and the Roxburn Oil Company, have been arranged for the afternoons.

The address to Section C, Geology, by Dr. J. S. Flett, on Experimental Geology, should be of general interest; the other papers will be more strictly geological, except the already-mentioned discussion on the Age of the Earth.

Section D, Zoology, is to be addressed by Professor E. S. Goodrich, on Some Problems in Evolution. Of the varied communications by Professor Arthur Thompson and others, we may mention Sir Sidney Harmer on Modern Whaling, Dr. J. Ritchie on Giant Squids on the Scottish Coast, and the joint discussion with Section I, Physiology, on Instinctive Behaviour.

Dr. D. G. Hogarth will deal with the Application of Geography in his address to Section E, Geography, and papers on the International 1 : 1,000,000 Map, by Lieut.-Colonel Winterbotham; on Aeronautical Maps, by Lieut.-Colonel F. E. W. Lees; on recent explorations, on Scotland and Edinburgh; and a discussion with Section L, Education, on the Teaching of Geography, will keep the Section busy. Sir Arthur Keith is going to raise the question of the Origin of the Scottish People, in a joint discussion with Section H, Anthropology.

In Section F, Economics, wages, currency and economy will be the prominent subjects. The presidential address by Mr. W. L. Hichens will treat the Principles by which Wages are determined; Miss G. Jebb will speak on the Cost of Living—Sliding Scales; Mr. A. A. Mitchell on the Breakdown of the Minimum Wage; Professor Kirkcaldy on Wage Systems; Mrs. B. Woottoon on Self-Supporting Industries; Sir Josiah Stamp on the Taxable Capacity of a Country; Mr. A. H. Gibson on Effects of the War on Credit, Currency and Exchanges; Professor D. H. McGregor on Trusts; Professor Edwin Cannan on Supply and Demand and Units of Currency, and Miss E. I. Stevenson on Public Expenditure—in fact, there will be a multitude of communications on the problems of economy, of which many of us fight shy. There is also to be a joint discussion with Section L, Education, on Vocational Training and Tests.

As regards Section G: Engineering, we published the full programme, list of papers and order in which they are to be read, on page 253 of our issue of August 12. The main problems to be discussed in this section will be water power and tidal power, the Mid-Scotland Canal, electric transmission, plant and supply, radiotelegraphy, high-speed pumps and the strength of materials.

Section H, Anthropology, will, apparently, have to dispense with a presidential address, if not with a president. The president elect, Sir James G. Frazer, has been obliged to go abroad before finishing his address. The proceedings of the Anthropologists are always very interesting to the outside member who finds time to attend them. That will also be so this year, when recent discoveries of palaeolithic art, and an Imperial School of Anthropology are to be discussed, and papers on Fairy and Witch Beliefs (Rev. J. A. MacCulloch), on Folk Lore in Uganda and other parts of Africa, in India and elsewhere are promised. Mr. A. W. Hilton will refer to the use of the Water Clock in Irrigation in Algiers.

With Section H, the number of Sections was exhausted at the time of the Edinburgh meeting of 1892. The further five Sections are more recent creations, upon which we can only touch briefly. In all these the presidential addresses will be subjects for discussion and not only for votes of thanks—a praiseworthy innovation. The President of I, Physiology, Sir W. Morley Fletcher, will deal with the Boundaries of Physiology, the President of J, Psychology, Professor J. Lloyd Morgan, with Consciousness and Unconsciousness. Important subjects in Section I are the Vitamines and Public Health (Dr. J. C. Drummond), the discussion on the Physiology of Heavy Muscular Work (Professor E. H. Cathcart and others), papers by Dr. Edridge-Green on Change of Hue by Dilution of Spectral Colours with White Light, and Dr. J. H. Shaxby, on the Testing of Colour Discrimination. Professor W. D. Halliburton's lecture on Giants should also be mentioned. In Section J, the discussions already referred to on Vocational Training and on Instinctive Behaviour, claim attention, and further a paper by Miss R. L. G. Ross, on Estimation of Vocational Fitness among Mental Defectives.

In Section K, Dr. D. H. Scott will, by his address on the Present Position of the Theory of Descent in relation to the Early History of Plants, invite a discussion of Darwinism, which it may be difficult to limit. Forestry problems and Forest Insects (Mr. Sutherland, Mr. W. J. Munro, Mr. Botherwick and others) will be among the chief subjects.

Section L, Education, also has a very useful programme. Sir Henry Hadow's address on the Place of Music in a Liberal Education, the papers on an International Language, on University Education and Reform (Mr. D. M. Cowan, M.P., and others), on the Ethical Value of Science (Dr. E. H. Griffiths), on the Preference of Pupils in Subjects of Study (Messrs. J. Don and J. Grigor), all deserve attention. How Mr. James McLaren will deal with his Simple method of Speaking English Phonetically, we do not know.

The Study of Agricultural Economics will be the subjects of the address of Mr. C. S. Orwin to Section M, Agriculture. The papers on the list concern agricultural education, farming, breeding, dairying, and food supply, and cover a wide range, and Dr. E. J. Russell will give a lecture to farmers on Science and Crop Production. The Relations of Genetics to Agriculture will be discussed in conjunction with Sections D and K.

There will be, in addition, the evening discourses by Professor C. E. Inglis, on A Comparison of the Forth and Quebec Bridges, showing the Evolution of Cantilever Bridge Construction during the past Thirty Years (on the Friday), and by Professor W. A. Herdman on Edinburgh and Oceanography (on the Tuesday). These discourses will be delivered like the President's address, in the Usher Hall. Sir Edward Roope, C.B., F.R.S., has chosen a wide subject for his address: Some Aspects and Problems of Post-War Science, Pure and Applied. We have further to mention the Conference of the Delegates, which its President, Sir Richard A. Gregory, will address, on the Message of Science; the address is to be followed by a discussion on Science and Citizenship.

The Citizens' Lectures, which are not intended for members of the Association, are entrusted to Sir Oliver Lodge, who will discourse on Speech through the Ether, to Professor A. Dendy, who will deal with The Stream of Life, and to Professor H. J. Fleure, whose subject will be Countries as Personalities. The already-mentioned lecture to farmers by Dr. Russell, is also announced as a citizens' lecture. The offices of the association at Burlington House, Piccadilly, will be closed on August 31, and the Reception Room in Parliament Hall, Edinburgh, will be opened at 2 p.m. on September 5.

LITERATURE.

The Location, Grading and Drainage of Highways. A Concise Discussion of General Principles Illustrated by Current and Recommended Practice. By Wilson G. Harger, C.E., Engineer, New York State Department of Highways. New York and London: McGraw-Hill Book Company, Inc. [Price 19s. net.]

Within the last few years American engineers have published some excellent treatises on road construction and maintenance, each surpassing the preceding in wealth of detail and elaboration of design, till in the present instance, no less than four volumes will be required to present the information collected and the experience gained by Mr. Harger in his close study of American practice. The problems arising from the use of motors and self-propelled vehicles have occasioned this inevitable extension. The roads constructed for comparatively light traffic have proved unsuitable for heavy truck traffic, and freight hauling, now carried on the highways, a species of transport that will increase as roads improve and new bridges are built. One type of road, the water-bound macadam, sufficed for all vehicular traffic, we now have to contemplate the advent of the weighty motor truck, requiring for its successful working a heavy, rigid type of pavement, the shortest possible distance between terminals, the elimination of needless rise and fall, easy grades and good alignment. Such roads are expensive to build. They are the necessity of thickly populated districts and may be regarded as the trunk lines of highway communication. They should be restricted to the use of vehicles having a gross load of some 15 tons, with a 10-ton back axle load, and a wheel pressure of 800 lb. per linear inch of width of tyre. To supplement these, and to accommodate the tractor trailer system, carrying a 10-ton gross vehicle load, a pavement of considerable foundation strength is required, but the perfect rigidity demanded in the former case is not essential. With still lighter traffic, some form of macadam, gravel or sand-clay will have to suffice the needs of less densely populated districts, till, in the neighbourhood of scattered farms, earth roads prove adequate. In the last case, the limited means available must be employed to produce the longest extent of mileage possible, in the first, the most suitable design for present conditions, regardless of cost, may be adopted.

This sounds axiomatic, but the author states, and we believe his remark is as applicable to this country as it is to America, that of late years there has been a tendency to construct and surface roads at a needless expense, or to favour through traffic to the detriment of local service. He urges that it is feasible by constructing roads to meet definite emergencies, to design a road system, in fact, that shall satisfy all exigencies, neither occasioning inconvenience to the manufacturer of trucks or interfering with the individual in the choice of a car. But the actual working out of a highway programme is rarely logical as there are too many conflicting interests to be considered. It is not uncommon for the highway engineer to forget the road user and the community and to think only of the improvements of technical detail, and there are always those who, remembering what untrained science and intuitions achieved in the past, are unwilling to seek assistance from wider experience and more scientific knowledge. One object which the author seeks to accomplish here is to convince well-meaning but uninstructed authority that the highway problem is not a simple matter, but requires special training on the part of the engineer. To bring this truth home more acutely to the commercial mind, the author quotes costs of construction in particular cases, which show that considerable savings might have been effected by the adoption of more scientific designs. In the one matter of grading, he states, that his examination of the plans of about 2,000 miles of road constructed in the last ten years had convinced him that a needless expenditure of at least 1,000,000 dols. had been incurred, which had no practical value whatever. Looked at broadly "About 75 per cent. of the plans showed a material expenditure of money for which no adequate return was obtained, amounting to from 5 per cent. to 20 per cent. of the cost. On some of the roads which, as built, served the traffic well, this excess might better have been spent on other jobs. On some of the roads which, as built, were not up to the requirements of the traffic, the waste might better have been applied to their own improvement in fundamental features." This is a grievous indictment and might be paralleled by instances nearer home. It enforces the need of providing scientific training for the executive staff engaged on the work. The reputation acquired from local knowledge of climatic conditions, of the quality of local stones and such like information, which form the stock-in-trade of many of our local road surveyors, will no longer suffice. It is Mr. Harger's purpose to insist on the road engineer being trained and recognised as a scientific authority, as one not slavishly following past methods but capable of initiating new plans that will effect judicious economies without reducing the usefulness of the roads. To judge from this first volume, which discusses the general principles governing the policy of highway structure and develops in detail the theory of economic location and grade line design, this purpose will be admirably fulfilled.

Though only a few broad, essential features of road construction are discussed in this volume, the vast amount of technical detail presented makes any adequate summary impossible. The general plan followed is to set out distinctly and saliently the objects to be gained, and to treat in detail the several factors which make for or against the achievement of those objects. There are, the author reminds us, a number of satisfactory ways of solving any problem, provided the general plan is sound and economic principles of design are applied. The adoption of a particular scheme frequently depends on the practical issue, whether the object proposed is worth the necessary expenditure. The balancing of cost of construction against utility, convenience, and economy is troublesome and at best is tentative, rather than final, for prices vary, machine design improves and traffic fluctuates. But the author's method is to be commended, for he does attempt quantitative analysis, and the results are trustworthy on the data employed. Some of the conclusions, based on data conditioned by the present state of motor design and fuel prices, are rather surprising. For instance, in discussing the matter of grading, the author decides that for ordinary motor-car driving "if for any reason a 6 per cent. grade cannot be obtained, you might just as well use a 10 per cent., and that heavy expenditure to get a 7 per cent. or an 8 per cent. has no bearing on the convenience of the road." In truck hauling, if a 4 per cent. grade cannot be provided, there is no object, from the standpoint of convenience, in using less than 8 per cent. grade. Further, good reasons are deduced for the contention that very little practical advantage results from reducing grades on local service roads below a reasonable maximum, where the distance and rise remains fixed. The fuel consumption remains practically the same, whether a long straight rate of grade or a succession of various rates is maintained.

Though grades and alignment are the fundamental permanent features of highway construction and improvement, there are other factors, as safety, convenience and economy, that have to be considered. These points include the determination of a safe driving slope, the pitch required to drain different surfaces, the width of the travelled way and the stable slopes for cut and fill outside the limits of the travelled section. These matters are fully treated from the point of design, not of construction, but various authors have treated these same questions, and there is no great room for originality. The remarks on Mountain Road Construction are interesting, though they have little application in this country. The diagrams of standard sections of highways adopted in different States are instructive and practical, but engineers must wait for the appearance of the third volume, to see the mechanical solution of many of the problems raised.

The last chapter is devoted to drainage, a term that is made to cover culvert and bridge construction. The author comments on the omission of adequate structures, reduction of reasonable water way, dangerous shortening of length, weakness for reasonable modern loads, and high waterways causing ponding, as indicative of poor economies. We are not sure but that the implied strictures are equally applicable in this country. The cost of ordinary culvert and small span bridge work does not generally exceed from 3 per cent. to 8 per cent. of the total cost of the road, and consequently designs, liberally conceived, do not add materially to the total cost of a road scheme. We gather that injudicious economy is often exhibited in these particulars, for it is stated that even in the richer States, the capacity of a modern road is occasionally limited in use by the retention of antiquated bridges. We look forward with interest to the appearance of the promised additional volumes.

The Economics of Welfare. By A. C. Pigou, M.A., Professor of Political Economy in the University of Cambridge. London: Macmillan and Co., Ltd., 1920. [Price 36s. net.]

Economic welfare assumes various aspects according to the position from which it is viewed. By some writers, the term has been restricted to the promotion of class interests and the furtherance of plans intended to ameliorate the conditions of manual labour. When identified closely with class interests, the term too often implies an elaborate and selfish organisation for giving one favoured class opportunity for injuring, or coercing, another. Professor Pigou understands rather the adoption of methods that aim at the bettering of human life as a whole, and his object is to trace the operation of causes, often obscure and involved, that affect the status of a community. The indulgence in polemic or the achievement of a party triumph has no place in his scheme, nor are the complicated analyses, pushed here to their legitimate conclusions, mere dialectic. One sternly practical object is to

inquire how welfare can be effected or increased by the introduction of causes which it is in the power of a statesman to call into being. Political economy is here exercising its proper function, and though the argument requires considerable analytical power to follow, and to draw a definite conclusion from the whole body of deductions giving to each its proper weight is a still more difficult task, yet to trace the steps in logical sequence, to mark the qualifications and restrictions that narrowly fence every proposition and to watch the action and reactions of causes under a great variety of circumstances is an illuminating and salutary exercise.

Disagreement from the author's conclusions will probably be frequent, for not only will prejudice and sentiment interfere with impartial judgment, but there are no means of measuring by a common standard, effects that operate unequally and in many directions. Beneficial effects produced by a known and definite cause may be cancelled or modified by effects of a contrary kind, brought about indirectly by the same cause. For instance, some material benefit may be welcomed for its immediate and palpable results, but if the conferment of that benefit bring about a deterioration of the recipients' character and independence, its latent effects can only become evident after a lapse of time, and if perceived at all will be very differently estimated by different judges, since no standard of measurement exists. The author is therefore careful to indicate, that he is not dealing with total welfare, but only with that form of welfare which can be conveniently described as economic, and whose results can be measured or referred to a money standard. How far the omission of the effects which cannot be submitted to the test of measurement invalidates the conclusions drawn from a necessarily partial analysis must be left to individual judgment. Some may think that the practical utility of the inquiry is destroyed. Such a decision would be far too sweeping. It is more reasonable to suppose, that in the aggregate these unestimated effects operate in the same direction as the measurable. But mathematical accuracy must not be expected, the results are admittedly approximate, and probability must be accepted where demonstration is impossible.

A more subtle argument, but one equally unsound, has been urged by a school of biologists who are disposed to treat these inquiries as possessing only a trivial or academic character. It raises the old problem of the relative importance of heredity and of environment. The contention of this school is that investigations dealing, as these do, with the national dividend and the uniformity of its distribution can only affect environment, and may therefore be compared to acquired characters which cannot be inherited. Hence such causes fail to react on the quality of the children born to those who enjoy the improvements. Hygiene, education and other desirable improvements, for which well-meaning philanthropists fight with more enthusiasm than knowledge, are but "fleeting palliatives at best, which in postponing, but augment the difficulties they profess to solve. Permanent progress is a question of breeding rather than of pedagogics, a matter of gametes not of training." On the other hand, neglect, poverty and parental ignorance, serious as their results are, possess no marked hereditary affect.

The supporters of heredity pursue the argument one step further and are perhaps justified in pointing out that the improved environment, if carried out, would enable feeble children to survive and thus tend to deteriorate the stock of future generations. The answer may be inadequate, but it is not without force, to urge that though the results from a biological point of view may be unrecognisable, yet socially they are beneficial, and we should not withhold our hand from what we can do, because other desirable efforts lie outside our limited capacity. Although environment may not directly effect germ-plasm, and we are powerless to attack the problem in its earliest stage, nevertheless it is certain that evil surroundings can influence disastrously the physically well-born from good stock. We understand this to be the plea of Mr. Sidney Webb, who argues that it is useless to rear babies from good stock, if they are allowed to grow up into bad men and women. "A world of well-born, but physically and morally perverted adults is not attractive." Professor Pigou maintains that the effects of environment need not be confined to the individual under its immediate influence, but that its consequences may prove enduring. Evidently we have to do here with a balancing of probabilities; one of those cases in fact in which beneficial effects may be cancelled by others originating from the same cause, and where having no hope of precise demonstration private judgment must be the arbiter. There will, however, be little dissent from the author's remark, that whether heredity or environment lead more quickly to the desired goal they "are of co-ordinate importance and the students of neither have the right to belittle the work of those who study the other."

Much of the divergence of opinion would disappear if it were possible to assign exact definitions and ensure precision by bringing a competent analysis to bear on this complex and involved subject. Evidently, however, a great practical service would be rendered, if we could predict the tendency, or trace the effect on welfare, of introducing some disturbing factor into the "national dividend" or income. But even such terms can hardly be defined without many discriminating reservations and a machinery for the accurate testing of results is inconceivable. In attempting to escape from the difficulty, the author considers the direction in which certain general movements, or variations in national prosperity, may be expected to affect the community in which the causes operate. He outlines four main propositions to serve as touchstones or guideposts, and generally decides that economic welfare will be increased or diminished according to the completeness with which the conditions are fulfilled. But these conditions react on each other and none is self-contained. It will be found, however, that the arrangement assists the marshalling of facts, fixes the attention on definite issues, and makes for lucidity of treatment.

Understanding by "national dividend," or income, the fruit of the activities of the people working in conjunction with the accumulated results of past activities and with the materials and forces provided by Nature, and dismissing the possibilities of forced labour from the scope of the inquiry, the author urges that any cause which increases the average volume of national dividend will increase economic welfare, provided that it neither injures the distribution nor augments the variability of the country's consumable income. One main reservation attached to the proposition is, that both the satisfaction yielded by consumption and the dissatisfaction involved in production have to be taken into account. The adjustment or balancing of final accounts requires, that there must be some point at which the satisfaction of adding to the dividend involves a greater loss than the indirect gain. Such a condition would arise if a man worked an undue number of hours per day; the extra labour would not be compensated by the satisfaction yielded by the greater product.

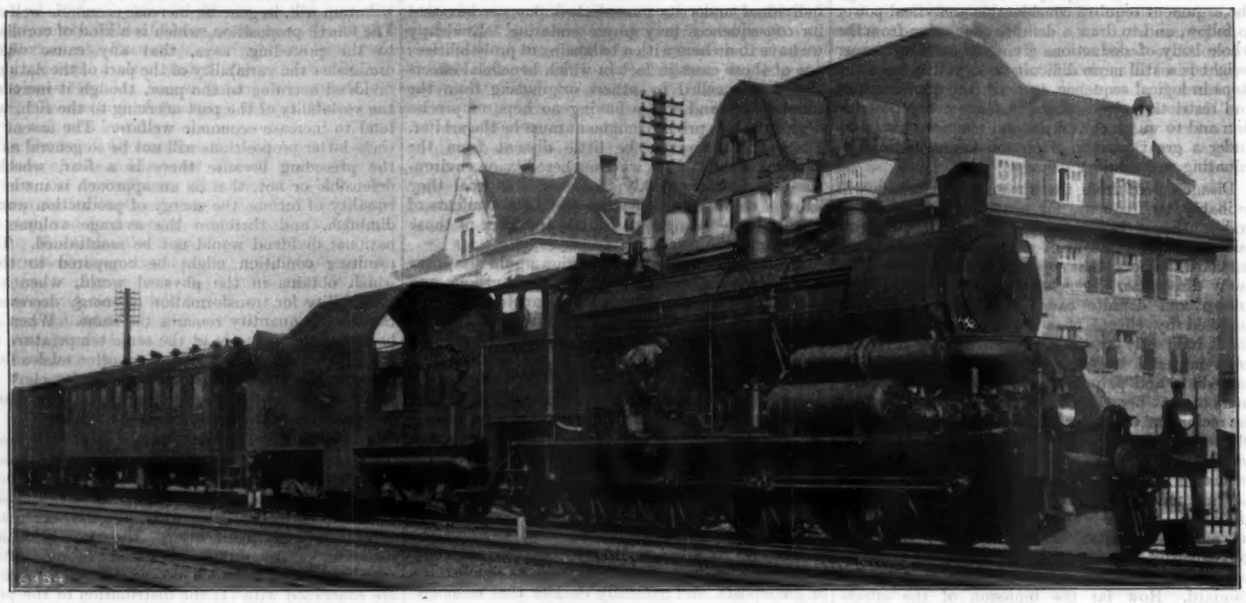
The second proposition states that keeping the national income and variability constant, any cause which increases the proportion of the national dividend received by poor persons will in general increase economic welfare. This deduction will perhaps be regarded as axiomatic. A poor person, whose definition the author does not attempt, from want of education or temperament may not make a good use of increased means, but after a time the possession of a large income will develop the capacities and faculties adapted for the enjoyment of a larger expenditure. It is strange how the spectre of unwieldy families is allowed to perplex the issue, for it is urged by some, that an increase of income would be accompanied by an increase of the population, until the income is reduced to the old level and consequently no permanent benefit would accrue. The alarm is needless: increased prosperity often brings a diminution of births, for as prosperity increases so do the pleasures that compete with marriage, and the demand for increased pleasure and refinement operates against the creation of large families. Infant mortality would diminish, but that is only another way of saying that economic welfare would increase.

The third proposition is thus expressed by the author: "Any cause which diminishes the variability of the national dividend, provided that it neither diminishes its volume nor injures its distribution will, in general, increase economic welfare. The fourth proposition, which is a kind of corollary to the preceding, says, that any cause which diminishes the variability of the part of the national dividend accruing to the poor, though it increases the variability of the part accruing to the rich, will tend to increase economic welfare. The assent to these latter propositions will not be so general as to the preceding because there is a fear, whether defensible or not, that as an approach is made to equality of income the energy of production would diminish, and therefore the average volume of national dividend would not be maintained. The resulting condition might be compared to that which obtains in the physical world, when the availability for transformation of energy decreases, though the quantity remains the same. When all bodies of a system are at the same temperature no work is obtainable. Analogies are often misleading, but it is possible to imagine a state of society in which the potential energy has disappeared, and only a useless state of kinetic energy remains.

In a review of this nature there is neither space nor occasion for detailed exposition, and if Professor Pigou's treatment is illuminating it is neither short nor simple. It must suffice to say that he discusses at considerable length, with all the necessary exceptions and qualifications, the way in which three important groups of influences affect the magnitude of the national income. These influences are concerned with (1) the distribution of the productive resources of the community among various uses or occupations, (2) those associated with the organisation of Labour, and (3) with the collection of revenue. It is only necessary to mention some of the questions that come prominently forward, to show at once both their interest and the impossibility of treating them here with any completeness. These include the incidence of taxation, the currency problems bequeathed by the war, the possibility of a return to the gold standard, the settlement of the fiduciary issue after normal conditions have been restored, and a special levy to pay off a large part of the national debt. On this last point, the author urges with considerable force, that a levy, which, ideally, should be assessed on both material and brain capital, would oil the wheels of production and increase the national dividend. There will be cases of individual hardship, however ingeniously the levy is adjusted, but on the other hand, there is no doubt that the maintenance of the *status quo* entails numerous cases of individual injustice.

Part V is devoted to the consideration of the share of the dividend enjoyed by the poor, when the volume of the national dividend is affected. Among the questions examined is an inquiry to determine the extent by which inventions and improved mechanism can effect the absolute state of labour. The conclusion is, that an invention that benefits the national dividend may, but very improbably will, diminish the real income of the poor. Another point to which we may listen with advantage, even if conviction is withheld, is the voice of science determining how far the forcing up of a wage rate of a group of workpeople will at the same time injure the national dividend, and increase the real income of labour as a whole. The final effect will depend on whether the workpeople are themselves purchasers of the goods they produce, and as workpeople are the purchasers of most commodities produced, the author decides that the outlook for a net gain is not very bright. But a decision is not conclusive, and the operation of various factors may turn the balance. A much larger question is the effect of the national dividend of direct transferences from the relatively rich to the relatively poor. Herein is perceived much of the tendency that characterises modern governments, and these "transferences," as the author euphemistically describes them, may be regarded as "sops to Cerberus," or attempts to satisfy, or at least to silence, a clamorous proletariat. Professor Pigou appears to think that the nation may travel indefinitely along this road with safety, but he constantly has before his eyes the dread possibility

THE ZOELLY STEAM TURBINE CONDENSING LOCOMOTIVE.



that the welfare of the whole nation may eventually suffer.

The last section, while devoted to an investigation of the principal causes which affect the variability of the national dividend, carries still further the inquiry into the operations of a communistic Government in relieving or assisting the manual labouring classes. The influencing causes are very intricate and the difficulty of appreciating the entire argument in its many bearings is very great. The answer to many of the questions is probably not to be found *a priori*, but in the old methods of time and experience, or "*solvitur ambulando.*"

The Case-Hardening of Steel. An Illustrated Exposition of the Change in Structure and Properties induced in Steels by Cementation and Allied Processes. By Harry Brearley. Second edition. London: Longmans, Green and Co. [Price 16*s.* net.]

This book has already an assured position as an excellent and useful guide to all matters concerning the case-hardening of steel, and the exhaustion of the first edition has enabled the author to revise and re-cast some of the chapters in the light of war experience. The result is a further enhancement of its value and we believe that there will be an even larger demand for the second edition than there was for the first.

The striking feature about all Mr. Brearley's publications is the originality of treatment and the freshness of his exposition. He is one of the few writers on metallurgical subjects who keep the facts and the explanation of the facts separate and distinct in his own mind, and who, brought up in a city of narrow tradition, has acquired traditional experience and yet retained the faculty of subjective criticism. His judgments are free from self-consciousness, but if they show at times a little wilful iconoclasm, the spirit of his science is always compassionate towards the good in the fragments.

Take the question of fibrous cores in case-hardened objects which are believed in blindly by all case-hardeners. In his own words, "A logical person with only a moderate faculty for criticism would not have much difficulty in revealing the slender basis of fact on which many cherished notions about case-hardened steels are supposed to rest. . . . Why, for example, should the core of a case-hardened object be better because it exhibits fibre and signs of toughness after the object is broken, or a high impact figure before the case has been formed? If toughness means ability to distort under stress, or, more picturesquely, ability to distort under impact stresses, then a high impact figure means the same thing, *i.e.*, extended distortion of the material during the breaking of a notched bar. For material to distort rather than break is undoubtedly advantageous, but, however soft, the material inside an envelope of glass-hard steel cannot distort, and it cannot exercise any toughness it might have until the case is broken or its restraint is otherwise partially or wholly removed. Let the sceptic screw up his finger in a vice, and see how much of its flexibility he can exercise, or let him grip a bunch of fingers in a pipe wrench if he would realise that neither toughness nor fibre count for anything and cannot be made manifest except in material which is free to move."

Is this not a case where the pleasure of breaking some of our revered idols is not just a little wilful? For Mr. Brearley knows just as well as anyone that a great many case-hardened objects are put into service with cracks in the case—either made during hardening or straightening, and it is not likely that he will assert that a crystalline core under such conditions would give as long a length of service as a fibrous one. Still, his method makes us think, and any stimulus to such an end leaves us, we hope, duly grateful.

The illustrations and printing in the book are excellent and the binding is sufficiently robust to withstand the repeated references which will inevitably be made to it by everyone who is fortunate enough to provide himself with a copy.

THE ZOELLY STEAM TURBINE CONDENSING LOCOMOTIVE.

An interesting locomotive is being put through trials on the Swiss Federal Railways, consisting of an engine fitted with a steam turbine and condensing plant. This engine has been designed and constructed by the Swiss Locomotive and Machine Works, Winterthur, in conjunction with Messrs. Escher Wyss and Co., of Zurich. Through the courtesy of the former firm we are able to illustrate it above, and to give some notes on its development.

The development is the outcome of work by Dr. Henri Zoelly, president of the Société des Ateliers de Constructions Mécaniques, Zurich, as a result of the coal shortage of 1918. A locomotive was placed, by the Swiss Federal Railways, at the disposal of the Swiss Locomotive and Machine Works, and Messrs. Escher Wyss and Co., for modification to Dr. Zoelly's designs. The locomotive frames carry the boiler in the usual way, and arranged in the front of the smoke-box, disposed across the machine will be noticed the steam turbine. The latter drives through double spur gearing a jackshaft placed across the frames, which in turn transmits the power to the driving wheels by means of side rods. The surface condenser is arranged between the frames under the boiler, the simplification of gear due to the use of the turbine making this space available. The condensing water, of which the temperature is raised by the steam, is cooled again by a current of air produced by the movement of the locomotive.

The apparatus in which this is effected is a long wrought iron casing, which will be seen on the tender, containing in its upper part a number of distributing tubes. Circulation is maintained by a small steam turbine-driven centrifugal pump which draws the water from the tender tank, passes it through the condenser and then passes it back to the re-cooler on the tender. The pipes in the latter have small perforations, and a fine spray of water is ejected into a current of air resulting from the speed of the locomotive. The loss of water as a result is said to be about one-half of the quantity required by the usual form of locomotive.

The locomotive has, up to the present, run trials aggregating about 471,667 ton-km., in ordinary railway service, and we are informed the condensing plant, circulating water re-cooler and the steam turbine have proved very successful. A good vacuum is said to have been obtained and maintained while running, and considerable economy over existing superheated steam locomotives is expected. Owing to the smaller consumption of water less has to be carried for the same distance, while the boiler has the advantage of being supplied with hot feed in the form of the condensate. This is at a temperature of about 50 deg. C., and is clean and free from oil. It is pumped to the boiler after having passed through a tubular feed heater, in which its temperature is further raised to 120 deg. C. As this condensate is used over and over again, and the loss only has to be made good with fresh water, the incrustation in the boiler should be considerably reduced.

The German Aluminium Industry.—Before the war Germany had only one aluminium works, at Rheinfelden in Baden, which was credited with an annual production of about 800 tons of aluminium. Several new works were built during the war, at Rummelsburg near Berlin, at Horrem near Köln, at Bitterfeld, at Grevenbroich on the Erft, at Steeg near Goysern, and the Lauta works in the Lausitz; a plant was projected also at Mühlendorf in Bavaria. Of these only the old Rheinfelden plant and the works at Bitterfeld (annual capacity, 4,000 tons), and the Erft and Lauta works (each with a capacity of 14,000 tons) remain in operation, according to a paper read by Dr. Sterner-Rainer before the Deutsche Gesellschaft für Metallkunde in July last. All the new works rely on electric power and lignite; only the Bavarian works will have hydroelectric power unless some of the other plants should be moved. In view of the uncertainty of the supply of the raw materials further developments are not likely at present. The problem of the utilisation of ordinary clay is being studied at several colleges, and the question of the recovery of aluminium from waste also receive particular attention. Dr. Rainer regretted that secrecy was still the rule in some aluminium works.

THE HYDRAUCONE REGAINER, ITS DEVELOPMENT AND APPLICATIONS IN HYDRO-ELECTRIC PLANTS.*

By W. M. WHITE, Milwaukee, Wis.

"HYDRAUCONE" is a new word coined for convenience in referring to the new method of transforming velocity head of fluids in motion into pressure head. This method consists in causing the stream flow to impinge upon some definite shape, either flat, conical or concave, thus changing its direction, and then placing an envelope around the shape so formed upon the particular base used, which envelope conforms to the shape of the fluid at entrance and gradually recedes from what would be the normal or free shape of the non-enclosed fluid impinging upon the particular base used; the effect of this gradually-diverging envelope being to change the velocity head of a fluid flowing at high velocity into its entrance into pressure and low velocity at its exit. The angle of divergence of the envelope from the normal or free shape of the impinging fluid is such as to bring about the same phenomena of flow conditions as result in an expanding straight-axis tube such as the discharge end of a Venturi meter. The new method therefore provides a means for transforming velocity head into pressure head within a short distance measured along the axis of the inflowing stream, and has useful application in water-power plants, supplanting the usual curved draught tube and providing for higher efficiencies with a minimum of excavation. For clearness reference is made in this discussion only to the single Francis-runner vertical water wheel unless otherwise stated.

The draught tube of a water wheel serves two purposes. The first of these is to maintain at the discharge side of the runner passages a suction action equivalent to the difference in elevation between the runner and the level of the tail water, thereby providing for the use of the total head. The second purpose is to transform the velocity head in the water as it is discharged from the runner into pressure head by the time the water reaches the end of the draught tube, and thus maintain at the discharge side of the runner passages a suction action greater than that which would be caused by the difference in elevation between the runner and the level of the tail water.

At first thought it seems like attempting to lift oneself with one's bootstraps to endeavour to utilise the energy in water after it has left the water-wheel runner, but this utilisation may be effected by an efficient transformation of the velocity head in the water discharged from the runner into pressure head, which causes an increased action at the runner and thus maintains a greater head acting on the runner than the total head as measured between the equivalent water level of the water at entrance to the water wheel and the level of the water in the tail race.

The necessity for an efficient means for regaining pressure from velocity of the water discharged from the water-wheel runner in modern plants has been brought about by the ever-increasing demand for higher speeds of water wheels for given conditions of power and head. The cost of electric generators of such sizes and speeds as are usually employed in water-power plants varies inversely as the speed, hence the buyer maintains a constant urge for higher water-wheel speeds, to meet which many high-speed types of runners have been brought out. As the specific speed of a runner increases, the percentage of energy it discharges also increases. A runner of moderate specific speed discharges water with such velocity that the energy contained in the water as velocity head is about 10 per cent. of the energy of the total head; and runners of highest specific speeds discharge the water at such velocity that the energy contained in it as velocity head is from 20 per cent. to 25 per cent. of the energy due to the total head acting on the water wheel. In order to secure high efficiency with high-speed runners it is therefore vital to regain the major portion of the energy contained in the water discharged from the runner for useful effect upon the water wheel, for as more of the energy which is discharged from the runner is regained, the efficiency of the water-power plant is increased.

A good illustration of the necessity for a better means of regaining the energy discharged from water-wheel runners is afforded by the installation at the Aluminium Company of America's plant at Massena, New York, where five 6,000-h.p. vertical two-runner water-wheel units are installed. Efficiency was of great importance, and the contract was placed with the manufacturer upon a bonus and penalty basis for efficiency, this being 6,000 dols. for each per cent. of efficiency per unit. The contract value of 1 per cent. increase in efficiency in this development was therefore 30,000 dols. Very elaborate tests were conducted by the Aluminium Company of America to determine the efficiency of these water wheels, the final results of which showed that the guaranteed efficiency was exceeded by about 2 per cent., yet the efficiency could have been increased very much more had a better form of draught tube been installed.

Experimental Work Resulting in the Development of the Hydraucone Regainer.—The necessity for a more efficient means of regaining pressure from velocity and changing the direction of flow from the water wheel within the limited space available in power-house foundations, led the writer to undertake a long series of experiments resulting in the development of the hydraucone regainer as set forth in the following pages.

An hydraulic laboratory was installed in a garage near the corner of Second and Wright Streets, Milwaukee, the essential equipment of which was as follows:—

A water-box, 6 ft. wide, 5 ft. 6 in. high and 32 ft. long.

A centrifugal pump of 14 in. discharge diameter, belt-driven by a 25-h.p. motor which served to supply a maximum of 14 cub. ft per second of water against a maximum head of about 15 ft.

A supply pipe leading from the centrifugal pump to a 42-in. diameter cylindrical plate-steel water-wheel casing with side inlet.

A water wheel equipped with wicket guide vanes.

A high-speed runner, being a 9 in. model of type No. 13, Allis-Chalmers Manufacturing Company. The discharge diameter of the runner where it joins the draught tube is 13¾ in. Specific speed, 90 (English system).

Also a prony brake, a tachometer, various Pitot tubes, gauges and manometers, &c.

The output of the water wheel under good testing conditions was about 8 h.p., so that the size of the equipment was sufficient to give a practical demonstration of the relative efficiencies of the draught tubes, hydraucone regainers and other devices tested.

A great many tests were made with many objects in view, and comprised tests with no draught tube; tests of straight conical and short curved draught tubes; Argo and Mio curved draught tubes; hydraucone regainers and cone centres, with conical plates, and with flat plates; a combination of straight draught tube and hydraucone regainer with flat plate; and a power-house model of a hydraucone regainer.

The hydraucone regainers with cone centres are shown at A and B in Fig. 1, and the hydraucone regainer with conical plates at C of the same figure. The hydraucone regainer with flat plate is shown in Fig. 2.

Fig. 3 shows a combination of a straight draught tube with a hydraucone regainer having flat plates. This type, now frequently employed, was the one installed at Niagara Falls, as will be more fully described later. Fig. 4 gives the dimensions of a model of hydraucone regainer such as has been installed in several power plants now in operation.

Figs. 5 and 6 show respectively the test curves plotted from the results of data obtained in the tests of the models of the Argo draught tube No. 1 and the hydraucone regainer with flat plate. It will be noted that the test results were all reduced to a basis of 1 ft. head before the results were plotted. Examination of these curves should convince any one that the tests must have been carefully conducted, and that the results may be relied upon to give at least a fair comparison of the relative efficiencies of the various devices tested. The identical water wheel, equipment and setting were used in all these tests.

Fig. 7 shows a series of efficiency curves plotted between

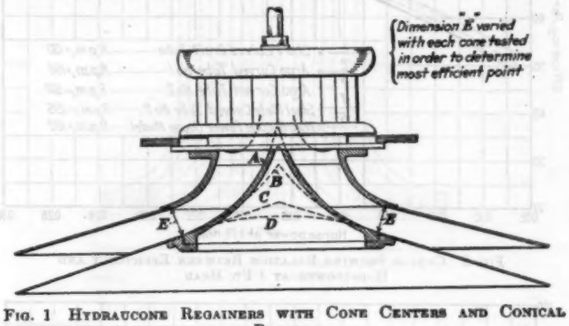


FIG. 1 HYDRAUCONE REGAINERS WITH CONE CENTERS AND CONICAL PLATES

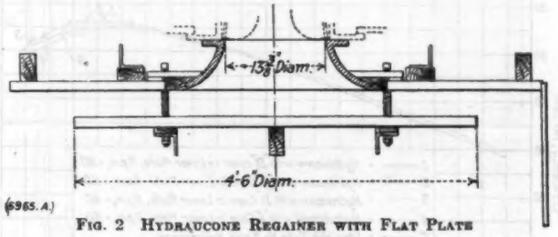


FIG. 2 HYDRAUCONE REGAINER WITH FLAT PLATE

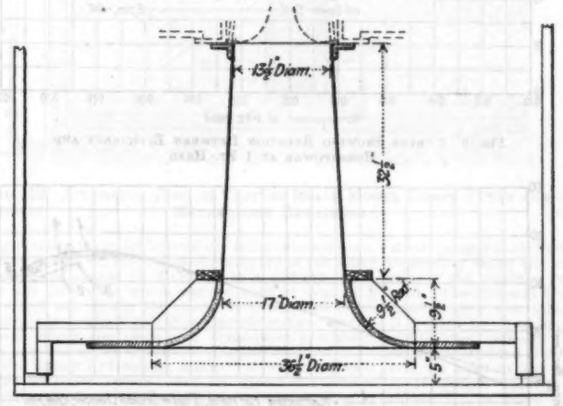


FIG. 3 COMBINATION OF STRAIGHT DRAFT TUBE AND HYDRAUCONE REGAINER WITH FLAT PLATE

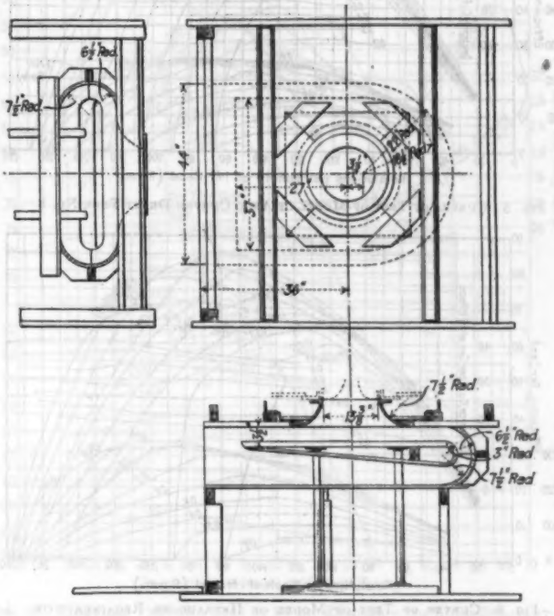


FIG. 4 DIMENSIONS OF MODEL OF HYDRAUCONE REGAINER USED IN A NUMBER OF POWER TESTS (6965.B.)

* Abstract of a paper presented at the Spring Meeting, Chicago, May 23 to 26, 1921, of the American Society of Mechanical Engineers.

horse-power and efficiency from test curves similar to those illustrated in Figs. 5 and 6. These curves give the efficiencies obtained at constant speed of the turbine throughout the range of the curves. The speed at 1 ft. head is indicated in the figure by the abbreviation "r.p.m.$_1$." The speed at best efficiency is different for each curve.

It will be noted that the more efficient the regaining device, the higher the speed as well as the higher the power of the water wheel. It will further be noted that the increase of efficiency from "no draught tube" as shown in Curve 1 to "hydraucone regainer" as shown in Curve 5 is from 77½ per cent. to 86 per cent., with an increase in speed from r.p.m.$_1$ = 155 to r.p.m.$_1$ = 165, and with a maximum power from h.p.$_1$ = 0·270 to h.p.$_1$ = 0·310. The great gain therefore, by the use of hydraucone regainers is not only in higher efficiency but is also in both speed and power.

Curve 1, Fig. 8, shows the efficiency of the short curved draught tube, which, it will be noted, is less than with no draught tube at all. There is no question but what many plants in operation to-day are losing power because of the poor curved tubes they use.

Curve 5, Fig. 8, shows the efficiency of the power-house model of hydraucone regainer whose dimensions are given in Fig. 4 and are approximately the same as those of the hydraucone regainer installed at the Hiram plant of the Cumberland County Power and Light Company, Portland, Maine.

Curve 4 gives the results of a test of a plate steel curved draught tube that are very creditable, but it is very rare that there can be installed in a power-house a draught tube of the same relative dimensions as those of the model employed, for the cost of excavation would be prohibitive.

Fig. 9 gives the results of tests with the hydraucone regainers shown in Fig. 1 and also with the straight tube and hydraucone regainer illustrated in Fig. 3. These curves are plotted from elaborate tests similar to those of Figs. 5 and 6 and show clearly that the hydraucone regainers with flat plates are slightly more efficient when tested with the model turbine than those with cone centres.

Fig. 10 represents the results of tests made on various shapes of conoidal chambers, from which it will be seen that the hydraucone regainer as here discussed is susceptible of a reasonable variation without materially affecting its efficiency.

The early tests at the laboratory were made to determine the effects on the model water wheel of radial passages extending outward but with a slight angle downward from the horizontal, and with passages leading directly from the runner. These early tests were not so successful as the later tests because it was not realised that in order to change the direction of the water from axial as it flowed from the runner to radial and outward, it was necessary to take into consideration and provide for what was afterward called the "hydraucone action" of water, which requires a definite curvature to change the direction of the water properly from axial to radial if the greatest regain of velocity head is to be expected and consequent losses are to be avoided. In searching for a means for increasing the efficiency of regain the author recalled some experimental work done in connection with the determination of the Pitot-tube formula in 1900, the results of which were published in Vol. xxii of the Journal of the Association of Engineering Societies (1901), page 284. Fig. 21 of

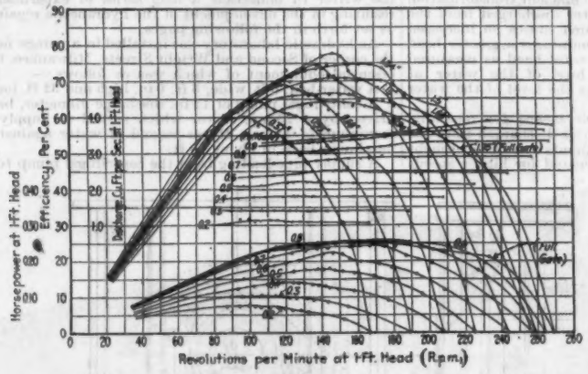


Fig. 5 Curves of Test of Model of Argo Curved Draft Tube No. 1

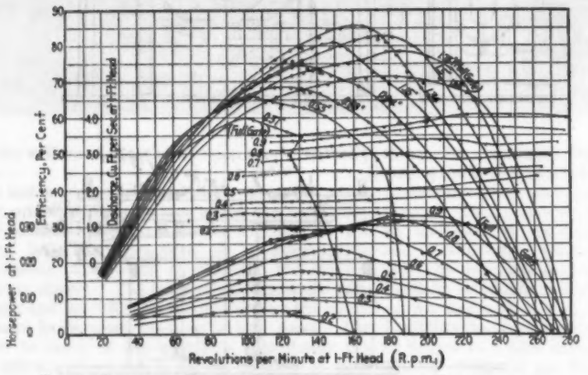


Fig. 6 Curves of Test of Model of Hydraucone Regainer with Flat Plate
(7½-in.-radius conoidal chamber, 4 ft. 6 in. in diameter)

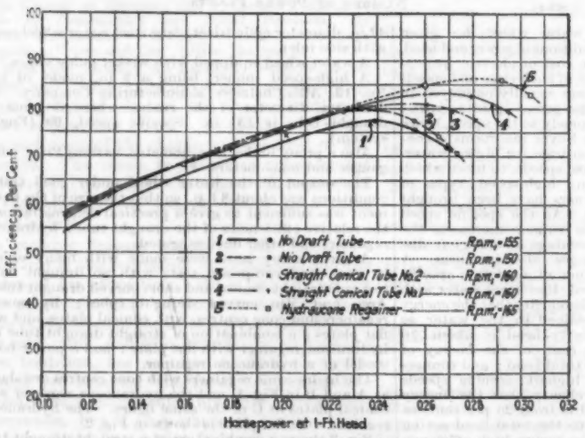

Efficiency, Per Cent
Horsepower at 1-Ft. Head
1 —— • No Draft Tube ——— R.p.m.$_1$ = 155
2 —— • No Draft Tube ——— R.p.m.$_1$ = 150
3 —— • Straight Conical Tube No. 2 ——— R.p.m.$_1$ = 150
4 —— • Straight Conical Tube No. 1 ——— R.p.m.$_1$ = 150
5 ---- ○ Hydraucone Regainer ——— R.p.m.$_1$ = 165

Fig. 7 Curves Showing Relation Between Efficiency and Horsepower at 1 Ft. Head
(5963.c)

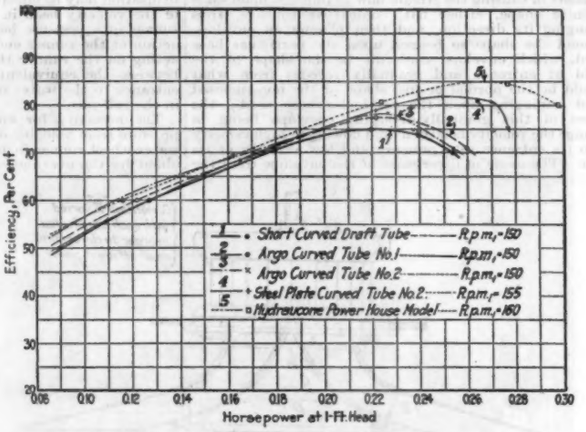

Efficiency, Per Cent
Horsepower at 1-Ft. Head
1 —— • Short Curved Draft Tube ——— R.p.m.$_1$ = 150
2 —— • Argo Curved Tube No. 1 ——— R.p.m.$_1$ = 150
3 —— × Argo Curved Tube No. 2 ——— R.p.m.$_1$ = 150
4 —— + Steel Plate Curved Tube No. 2 ——— R.p.m.$_1$ = 155
5 ---- ○ Hydraucone Power House Model ——— R.p.m.$_1$ = 160

Fig. 8 Curves Showing Relation Between Efficiency and Horsepower at 1 Ft. Head

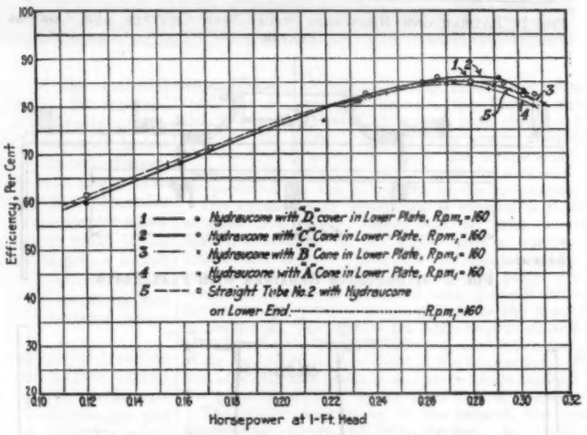

Efficiency, Per Cent
Horsepower at 1-Ft. Head
1 —— • Hydraucone with "D" cover in Lower Plate, R.p.m.$_1$ = 160
2 —— • Hydraucone with "C" Cone in Lower Plate, R.p.m.$_1$ = 160
3 —— • Hydraucone with "B" Cone in Lower Plate, R.p.m.$_1$ = 160
4 —— • Hydraucone with "A" Cone in Lower Plate, R.p.m.$_1$ = 160
5 ---- ○ Straight Tube No. 2 with Hydraucone on Lower End ——— R.p.m.$_1$ = 160

Fig. 9 Curves Showing Relation Between Efficiency and Horsepower at 1 Ft. Head

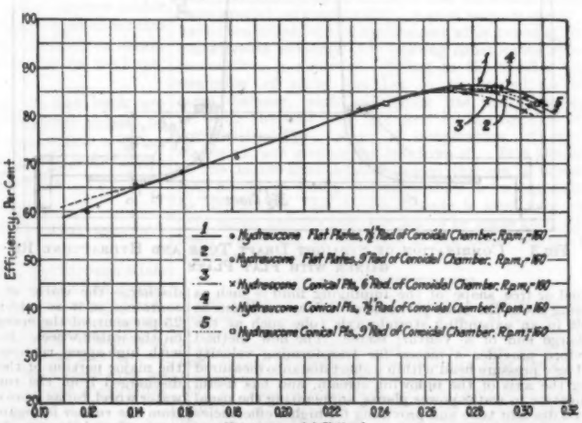

Efficiency, Per Cent
Horsepower at 1-Ft. Head
1 • Hydraucone Flat Plates, ¾" Rad. of Conoidal Chamber, R.p.m.$_1$ = 150
2 ○ Hydraucone Flat Plates, 9" Rad. of Conoidal Chamber, R.p.m.$_1$ = 150
3 × Hydraucone Conical Pts, 6" Rad. of Conoidal Chamber, R.p.m.$_1$ = 150
4 + Hydraucone Conical Pts, ¾" Rad. of Conoidal Chamber, R.p.m.$_1$ = 150
5 ○ Hydraucone Conical Pts, 9" Rad. of Conoidal Chamber, R.p.m.$_1$ = 150

Fig. 10 Curves Showing Relation Between Efficiency and Horsepower at 1 Ft. Head
(5965.a)

that publication shows the stream lines and velocities of a jet impinging upon a plate, and by reason of the importance of the principle there disclosed in the new method of regaining pressure from velocity, it is reproduced here as Fig. 11.

The lines in this figure represent the stream lines of flow of the water, which were traced by injecting a small stream of blue water into the jet at various points along a diameter and noting and recording the flow line. The plate employed in this case was made of glass in order to afford ample light for making the observations. The figures given in the circles represent the velocities in feet per second at the various locations indicated. It will be noted that the water at the centre of the jet slows up as it reaches the plate and delivers its velocity head into pressure head at the centre of the place. This pressure head at the centre is transformed into velocity as this stream flow passes from the centre of the point of

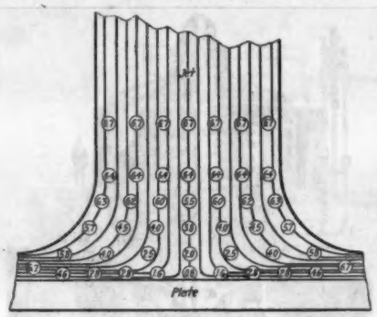


FIG. 11 HYDRAUCONE ACTION OF WATER WHEN A JET IMPINGES NORMALLY ON A FLAT PLATE
(6965.E.)

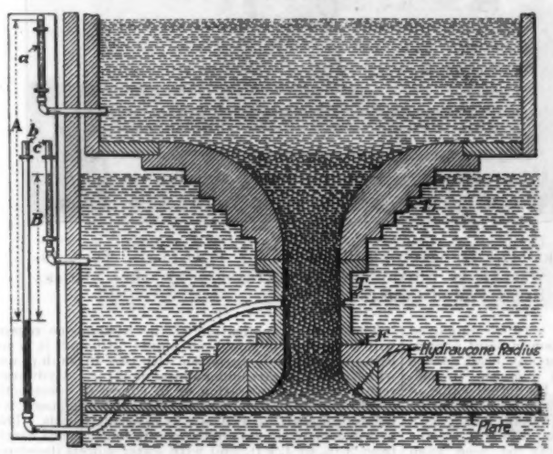


FIG. 12 APPARATUS USED IN TESTING SMALL MODEL DRAFT TUBES AND HYDRAUCONE REGAINERS
(6965.F.)

impingement to the point beyond the radius of curvature. Referring to Fig. 11, the radius of curvature of the water in making its change in direction is a definite curve and is the minimum which can be used in regaining devices and yet obtain the reactions within the point of impingement which will give smooth stream flow of discharge along the plate and consequently without eddies and attendant losses.

By the term "hydraucone action" of water is meant that action which occurs when an unenclosed stream impinges against and is deflected along a surface. Fig. 11 illustrates the hydraucone action of water when a jet impinges normally upon a flat plate. In considering the three outer stream filaments it was noted and recorded in 1900 that the cross-sectional area of the flow increased in making the turn and decreased at the exit from the turn. By placing a cone on the plate with its axis in line with the centre line of the jet the outer shape of the curvature of the water is changed, but not to a great extent because of the low velocities within the centre portion of the impinging jet.

When the hydraucone action of the water as illustrated in Fig. 11 was taken into consideration in the laboratory work, conoidal chambers were designed such as one shown in Fig. 2, and when these were combined with the radial passages the desired results were immediately secured.

Tests of Smaller Models.—The tests of the various model draught tubes and hydraucone regainers made at the laboratory with the small turbine illustrate the practical, economical and efficient application of the hydraucone principle for increasing the efficiency of water-power developments. Coincident with the series of tests in connection with the small turbine, a series of tests on smaller models was made without the use of a model water wheel. Sometimes these small models were tested before the large models were built and tested with the turbine, and sometimes afterward. These models were all made of such size that the entrance was 4 in. in diameter at the throat as compared with 13⅛ in. at the throat of the larger models.

The apparatus used for testing the small models is shown in Fig. 12. The model water wheel was removed from the plate-steel cylindrical casing, and in its place the curved wooden section L was bolted to the opening at the bottom of the casing. At the bottom of the curved piece L was connected a 4-in. diameter throat T, made of brass pipe with flanges, to the lower end of which the various small models were fastened. Four piezometer openings and as many gauges were provided to indicate accurately the pressure at the throat. Gauges *a*, *b* and *c* serve to illustrate more or less diagrammatically the method of computing the efficiencies of the small models. The difference in elevation between gauges *a* and *c* was kept about the same. The reading of the throat gauge *b* varied widely, depending upon the efficiency of the regainer device used. The efficiency of these small models was taken as B divided by A, or in other words, the velocity head regained divided by total velocity head in the water as it passed through the throat T. A small model hydraucone was attached to the throat in Fig. 12. The model hydraucone was detachable from the flange F of the throat, to which were bolted the various devices tested.

Tests were made with the hydraucone regainers having cones in the centre of the chamber, and the distance between the plates was varied. With a tall cone in the centre similar to A, Fig. 1, the efficiency obtained was less than 70 per cent. By substituting a low cone similar to that represented by B in the same figure, the maximum efficiency by varying the distance between the plates was found to be 70 per cent.

One series of tests copied from the record book of a model hydraucone as shown in Fig. 12, having a 2¾-in. radius of curvature of the conoidal chamber, gave the following efficiencies as the distance between the plates was varied :—

Distance between plates, inch ...	½	9/16	⅝	11/16	¾	⅞	1
Efficiency, per cent.	76·7	77	78·5	78·7	78	74	68

By cutting down the diameter of the upper and lower plates to 18 in., using the same radius of curvature of the conoidal chamber, namely, 2¾ in., and varying the distance between the plates, the following efficiencies were obtained :—

Distance between plates, inch ...	½	9/16	⅝	11/16	¾	⅞
Efficiency, per cent.	61	65·5	67·5	67	68·8	59·3

Conoidal chambers of various radii of curvature were tested with cone centres, flat plates, and then with depressions or concave surfaces, the latter being developed to secure shorter radius of curvature of the conoidal chamber. The efficiencies obtained with the concave surfaces were about equal to that obtained by the use of the flat plate when the proper curve of the conoidal chamber was used.

Tests were also made upon straight conical and curved draft tubes, and upon square expanding nozzles and

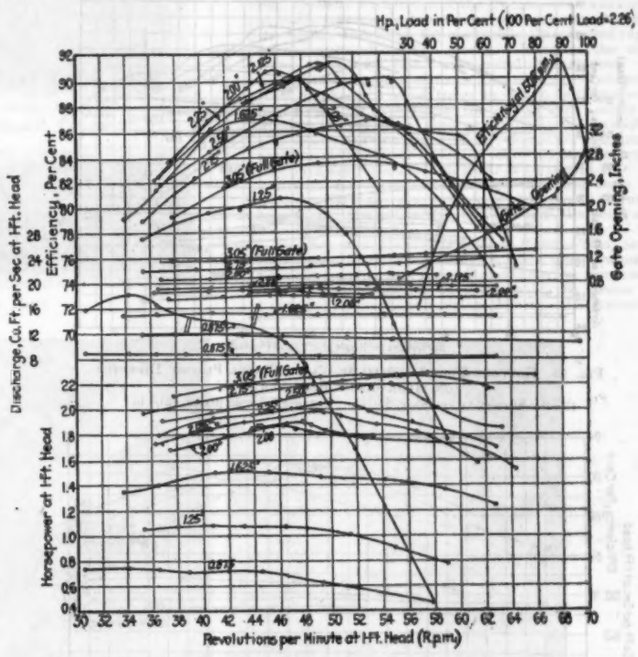


FIG. 13 HOLYOKE TEST NO. 2445 OF 30-IN. RUNNER WITH LONG STRAIGHT CONICAL DRAFT TUBE
(6965.G.) (20 guide vanes; guide case 14¼ in. wide.)

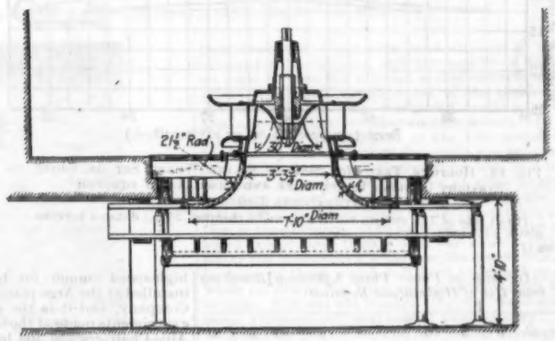


FIG. 14 WATER WHEEL PLACED DIRECTLY ON HYDRAUCONE REGAINER AS IN HOLYOKE TEST NO. 2460
(6965.H.)

elliptical-shaped nozzles as contrasted with the circular straight nozzles. Rectangular and conoidal bends were also tried out.

Holyoke Tests.—At the completion of the tests of the various regainers and model draught tubes at the laboratory, a series of tests was made at the Holyoke Testing Flume on a large water wheel having a runner of 30 in. nominal diameter and a discharge diameter of 38 in. The object of these tests was to verify the results already obtained at the laboratory, and to obtain records of the performance of the hydraucone regainer which could be presented to the engineering profession with the assurance that they were reliable, and could be used for comparison with the results obtained with other forms of draught tubes tested at Holyoke. The water wheel was first tested with a straight draught tube, 8 ft. 3½ in. in length and with diameters of 3 ft. 3½ in. and 6 ft. 3 in. at the smaller and larger ends, respectively. This was the best tube of this type developed by the Allis-Chalmers Manufacturing Company for testing purposes. The results of the tests are shown in Fig. 13, Holyoke test No. 2,445, dated March 3, 1916.

The next test was made by placing the water wheel directly on the hydraucone regainer as shown in Fig. 14, and the results are given in Fig. 15, Holyoke test No. 2,460, dated May 5, 1916. Fig. 16 gives the results of a test of the water wheel when set on a short straight conical draught tube (3 ft. long), with the discharge of the tube connected with the hydraucone regainer. (Holyoke test No. 2,461, dated May 10, 1916.)

Two shapes of conoidal chambers were made and tested, one of which is illustrated in Fig. 14. Tests were made with the plates of the hydraucone regainer set at various distances apart. These tests confirmed those made at the laboratory and showed that the hydraucone regainer could be relied upon for giving high efficiency with commercial water wheels under actual operating conditions. A maximum efficiency of 91·6 per cent. was obtained with the use of the hydraucone regainer characteristics at speeds both below and above normal than the test with the straight draught tube, all of which might be expected in view of the radial passages of the hydraucone regainer in which the whirling action of the water is utilised for increasing the efficiency.

Hydraucone regainers with cone centres such as A, Fig. 1, were not tested at Holyoke because the laboratory experiments showed conclusively that hydraucone regainers with flat plates gave better efficiency. The friction of the water along the surface of a hard cone centre is much greater than the internal friction when the water forms its own cone as shown in Fig. 11. This is one reason why the hydraucone regainer with flat plate gives better efficiency than the hydraucone regainer with cone centre.

Results Obtainable by Using Hydraucone Regainers with Runners of Different Specific Speeds.—The hydraucone regainer may be employed in any power plant operating under any head with a resulting increase in efficiency. Its actual value in power plants operating under different heads with runners of different specific speed may be seen from Table I.

Runner No. 1 is a type identical with that used on one of the 37,500-h.p. turbines recently put into operation in Station No. 3 Extension of the Niagara Falls Power Company. The specific speed of this runner is about 40 (English system). Runner No. 2 is a reasonably high-speed runner for low-head plants, such as that installed at the Argo plant of the Eastern Michigan Power Company, and it is the same type as that used in the experiments made at the laboratory. Runner No. 3 is the Allis-Chalmers No. 404 high-speed type furnished to the Cheboygan Electric Light and Power Company, Cheboygan, Mich. This runner was described by Mr. Nagler in his paper presented at the 1919 annual meeting of the society.* The axial component of the velocity of the water discharging from each runner is shown in column 6. The energy discharged from the runner in each case is shown to be respectively 4 per cent., 13·7 per cent., 22·4 per cent. of the energy of the total head. Draught tubes on high-head plants are usually much more efficient than those on low-head plants. A draught-tube efficiency of 40 per cent. may be obtained under ideal conditions in a suitable curved draught tube for use in connection with runner No. 1, but draught tubes on low-head plants are not so efficient, and the efficiency of a curved draught tube such as would be used with runner No. 2 would be about 20 per cent., and with runner No. 3 certainly not exceeding 20 per cent.

The efficiency of the hydraucone regainer for use with each of the three runners would be at least 70 per cent. The greater efficiency of the hydraucone regainer over the curved draught tube results in increasing the power-plant efficiency by 1·2 per cent., 6·9 per cent. and 11·2 per cent., respectively, for runners Nos. 1, 2 and 3, as shown by column 12 of Table I. From this it will be seen that the use of the hydraucone regainer on low-head plants is almost a necessity if reasonably good efficiencies are to be obtained. These comparative efficiencies are based on the wheels operating at their best speed and best efficiency, that is, when the discharge from the runner is nearly axial. At any other speed or gate opening the discharge of the water wheel is accompanied by more or less whirling, that is, the absolute velocity of the water leaving the runner is much greater at full load than given in Table I. Furthermore, the whirling action of the water in the discharge is much more effectively used in the hydraucone regainer than it is in the curved draught tube, because of the radially-extending passages within which this whirling action produces outward pressure by centrifugal force.

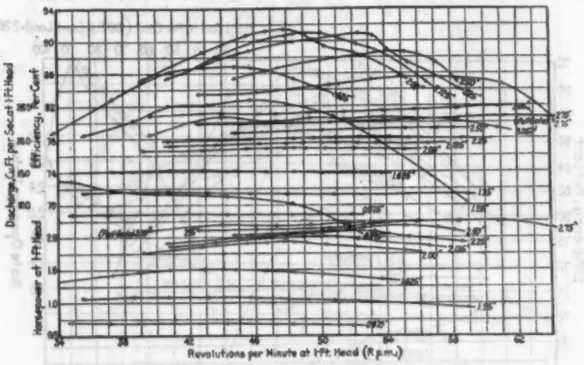


Fig. 15. Holyoke Test No. 2460 of Water Wheel Placed Directly on Hydraucone Regainer

(Radius of conoidal chamber, 21½ in.; distance between plates, 12½ in.)

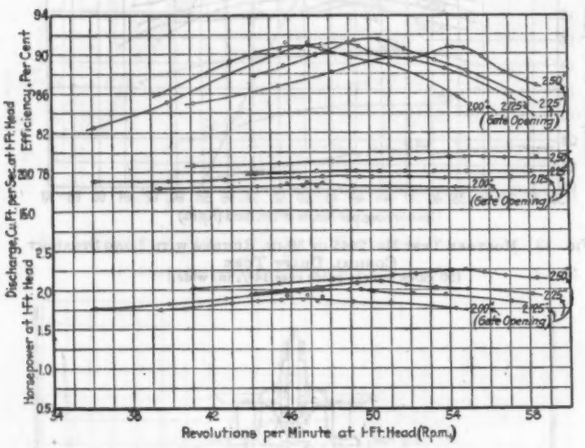

Discharge, Cu.Ft. per Sec. at 1 Ft. Head
Efficiency, Per Cent
Horsepower at 1 Ft. Head
Revolutions per Minute at 1 Ft. Head (R.p.m.)
(Gate Opening)

Fig. 16. Holyoke Test No. 2461 of Water Wheel Set on Short Straight Conical Draft Tube and Discharging through a Hydraucone Regainer

(Draft tube of 3 ft. section; radius of conoidal chamber, 25 in.; distance between plates, 12½ in.)

(9368.i.)

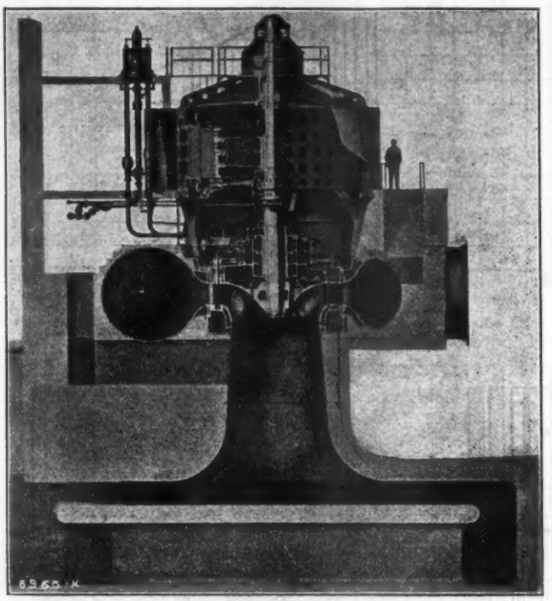


Fig. 17. Hydraucone Regainer of Flat-Plate Type Installed in Station No. 3 Extension of the Niagara Falls Power Company.

The field of application of the hydraucone regainer will be greater on low-head plants, although it is now being installed in connection with two 40,000-h.p. units which are to operate under a head of 421 ft. Hydraucone regainers are in operation or in course of construction in 25 hydro-electric power plants, being used with horizontal shaft as well as vertical-shaft wheels. These hydraucone regainers are to operate under heads varying from 8 ft. to 421 ft. and with water wheels developing from 150 h.p. to 40,000 h.p.

The most notable installation of the hydraucone is that in Station No. 3 Extension of the Niagara Falls Power Company at Niagara Falls, New York. Unit No. 16 is equipped with a hydraucone regainer of the flat-plate type, as shown in Fig. 17. At the time of the purchase of the water wheel for this unit it was still argued by some that curved draught tubes of proper design would give as high an efficiency as that claimed for the hydraucone regainer. The engineers of the power company accordingly conducted a long series of experiments with various devices, which finally resulted in the development of a conoidal chamber with a cone centre similar to that shown in Fig. 1 for units Nos. 16 and 17. The best model with cone centre had the proper-shaped conoidal chamber for regain, and when the cone centre was removed from the model, it was found that the efficiency was no lower than with the cone in place. The use of the new substitutes for curved draught tubes at this plant resulted in a water-wheel efficiency of 93 per cent. being obtained, which is corroborative evidence of the value of the hydraucone principle for the regaining of pressure from velocity.

Everyone familiar with hydro-electric power-house operation where curved draught tubes are employed has frequently noticed the boiling and disturbance of the water at the outlet from the curved tubes. This disturbance is clearly an evidence of inefficiency and loss of energy which should be more effectively utilised. The hydraucone regainer provides a means for efficiently regaining the energy discharged from the runner for useful effect upon the water wheel within the limited space available in the power-house foundations.

Table I.—*Increase in Power Plant Efficiency Resulting from Use of Hydraucone Regainer.*

1	2	3	4	5	6	7	8	9	10	11	12
Number of Runner.	Specific Speed.	Nominal Diameter of Runner. Inches.	Discharge Diameter of the Runner. Inches.	Cubic Feet per Second Discharged at 1 Ft. Head.	Vertical Component of Water Discharged from the Runner.	Energy in Discharged Water. Per Cent.	Assumed Efficiency of Draft Tube. Per Cent.	Loss of Energy with Draft Tube. Per Cent.	Assumed Efficiency of Hydraucone Regainer. Per Cent.	Loss of Energy by Hydraucone. Per Cent.	Increase of Efficiency by Use of Hydraucone. Per Cent.
1	40	30	28	1·97	1·65	4	40	2·40	70	1·2	1·2
2	90	30	44·5	32·05	2·97	13·7	20	11	70	4·1	6·9
3	160	30	30	18·5	3·8	22·4	20	17·9	70	6·7	11·2

as shown by Holyoke test No. 2,461, which was slightly greater than that obtained with the long straight draught tube in Holyoke test No. 2,445. The test of the water wheel with the hydraucone regainer showed better

* A New Type of Hydraulic-Turbine Runner. Forrest Nagler, Trans. Am.Soc.M.E., vol. xli, page 829.

Industrial Lantern Slides.—Messrs. Marshall, Sons and Co., Limited, Britannia Iron Works, Gainsborough, state that they will be glad to loan lantern slides illustrating their steam engines, boilers, &c., suitable for lecture purposes at engineering colleges, technical schools, &c., during the coming winter session.

THE SEASON-CRACKING OF BRASS AND OTHER COPPER ALLOYS.*

By H. MOORE, O.B.E., B.Sc., F.I.C., Member; S. BECKINSALE, B.Sc., A.I.C.; and CLARICE E. MALLINSON, M.B.E., B.Sc.

(Communication from the Research Department, Woolwich.)

(*Continued from page* 264.)

4. *Rods and Tubes.*—Season-cracking on a considerable scale had occurred in a store where large stocks of cold-drawn brass rods and tubes used for the manufacture of small machined parts had been kept over prolonged periods. The rods and tubes were stored in bundles in wooden racks, and were supported at every few feet along their length. It had been noted that cracking was most prevalent in the winter, especially when a low temperature following mild weather caused the formation of heavy deposits of moisture on the rods, &c. The evaporation of the moisture commonly left a corroded surface. The cracked rods were usually in the outer layers of the bundles. A number of typical specimens with and without cracks were selected for examination. A rod and a tube are illustrated in Figs. 10 and 11. It was very noticeable that the cracks occurred chiefly in the corroded regions. Many of the rods and tubes were corroded or tarnished much more on one side than the other and the preference of the cracks for the corroded side was quite marked.

FIG. 10. LONGITUDINAL SEASON-CRACK IN WALL OF BRASS TUBE.

FIG. 11. TRANSVERSE SEASON-CRACKS IN BRASS ROD.

FIG. 12.

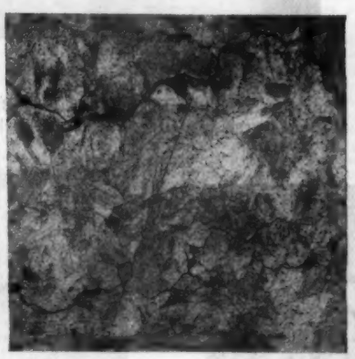


FIG. 13.

FIG. 14.

SEASON-CRACKS IN 70:30 BRASS, GENERALLY FOLLOWING AN INTERCRYSTALLINE PATH. × 100.

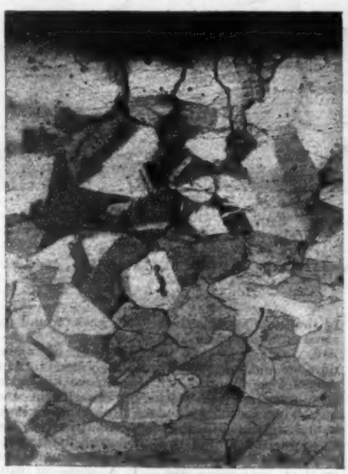


FIG. 15.

FIG. 16.

SEASON-CRACKS IN 70:30 BRASS CORRODED ON THE SURFACE. SHOWING INTERCRYSTALLINE PATH AND CORROSION AT EDGE OF SECTION (ORIGINAL SURFACE). × 100.

Microscopic Examination.—Transverse and longitudinal axial sections from near the ends and middle of each of the rods and tubes were examined before and after etching with a solution of ammonium persulphate and ammonia. The composition indicated structures consisting entirely of α, entirely of β, and of a mixture of α and β each represented by several samples. The crystal size was very variable. The 1 in. round rods consisted entirely of the β constituent; two of these had a fine structure in an outer layer, changing suddenly to a coarser structure in the inner region; in one of these rods some of the cracks were circumferential in direction, following roughly the boundary between the fine and the coarse regions. Cold-work effects (*e.g.*, elongation of the crystals) were present in different degree. Generally the structures showed great variety, within the limits possible for the compositions found, and had little in common. As a rule, the cracks were intercrystalline, but in some cases an intercrystalline crack approaching a crystal in a direction approximately normal to its face cut through the crystal instead of following the boundary. Cracks running longitudinally, transversely, and in other directions were found, though in a particular specimen cracks of one direction usually predominated. Very frequently complex branching of cracks were noticed. Corrosion often accompanied the crack, usually at the outside surface, but frequently also in the interior of the rod. Selective corrosion of the β constituent was noticed in badly corroded α β structures and was very marked in the square rods (Fig. 19), in which badly corroded regions were connected by fine cracks. Many of the cracks were extremely fine. Non-metallic inclusions were numerous in some specimens, but were rarely connected with cracks. In some tubes in which both coarse and fine structures were found the cracks were mainly confined to the regions of large crystallization. In addition to the microsection Fig. 19 here referred to, other microsections showing season-cracks following an intercrystalline path are reproduced in Figs. 12 to 18 and 20.

Brinell Hardness Tests.—Brinell hardness tests were made on the transverse sections of rods used in the microscopic examination, with a ball of 2 mm. diameter and a load of 40 kg.

Pickling and Mercurous Nitrate Tests.—Two, and in some cases, three, 2-in. lengths were taken, whenever possible, from parts of the rods and tubes free from season-cracks. After pickling in nitric acid the pieces were examined for cracks and surface defects. They were then immersed in a 1 per cent. acid solution of mercurous nitrate for five minutes, and were examined immediately on removal from the solution and afterwards at frequent intervals. Visual examination of the pickled sections showed that only very rarely did cracks coincide with scoring marks, laps, or other surface defects. In coarsely crystalline specimens, such as the 1-in. round bar DE, the intercrystalline path of the cracks was apparent to the eye, although a crack approaching the middle of an elongated crystal approximately at right angles to its boundary would sometimes pass through the crystal; a similar observation made in the microscopic examination is noted above. The sections from all the rods and tubes except those from a 1-in. bar marked DD cracked under the mercurous nitrate test, the cracks being similar in form to those which had been produced on storage, while no cracks ran from surface defects such as scores or laps. DD was not cracked forty-two days after treatment, although still well coated with mercury. In some of the badly cracked bars no new cracks developed under the mercurous nitrate test, but cracks present before testing extended farther. Cracks similar to the wide gaping cracks found in some bars after storage were also produced by the mercurous nitrate test.

Tensile Tests.—Wherever possible, tensile tests were made on test-pieces cut from the bars and tubes. The test-pieces were as large as could be obtained. Extension was measured during loading by the Cambridge extensometer, which is sufficiently robust to withstand the unexpected breaking of a flawed test-piece. The limit of proportionality was derived directly from the extensometer readings taken at increments of load of 1 ton per square inch; the yield point was taken from the plotted load-extension diagram. The acting length on which the elongation was measured was in all cases equal to $4\sqrt{\text{area}}$.

Measurements of Stress.—Heyn's method of determining the magnitude of internal stresses present was applied to pieces of two of the 1-in. round rods, viz., DE, which had developed season-cracks in store and had also cracked under the mercurous nitrate test, and DD, in which no cracks had formed in store or under test. As the transverse cracking of DE had partially relieved the longitudinal stresses the measurement could indicate the residual stress only. The specimens were 2·2 in. in length. A circumferential line was scribed 0·1 in. from

*Abstract of a paper read at the meeting of the Institute of Metals on Thursday, March 10, 1921.

each end. Successive layers 0·0125 in. thick were removed from a central length of 1·8 in. by turning, and the distance between the two scribed lines was measured with a measuring microscope before turning and after each reduction in diameter. In several specimens from DD no change in length occurred, while in similar specimens from DE the distance between the scribed lines increased after the removal of each layer. Application of the formula used by Heyn to the figures obtained indicated a residual longitudinal tension stress of 10 tons per square inch in the outer layers of the rod DE. The rod DD was apparently free from longitudinal stress.

Examination of Corrosion Product.—The corroded fracture-surfaces of the cracks were green in most cases, but a dull brown in some specimens. Small specks of dark blue corrosion product were observed on some of the fractures. Tests for the presence of ammonia and nitrates were made by the well-known delicate methods. The Nessler solution used was made up as described in the Appendix and the diphenylamine solution by dissolving 0·5 grm. diphenylamine in 100 cc. of pure sulphuric acid to which 20 cc. of distilled water had been added.

(*a*) *Test for Ammonia.*—Parts of the corroded fractures were carefully cut away with a fret-saw and immersed in 5 c.c. of distilled water, care being taken that the tubes and distilled water were free from all traces of ammonia. Pieces of the same rods and tubes were cut, cleaned with emery cloth to remove all tarnish, and were broken, giving fibrous fractures. The fractured pieces were immersed in 5 c.c. distilled water in a similar way. The fractures were left in the distilled water for one day, while a tube containing distilled water only was kept under the same conditions. 1 c.c. of Nessler's solution was added to each tube. About five minutes after the addition of the Nessler reagent, the tube containing the water extract from the corroded fractures had become brown, and later a slight precipitate developed, while the contents of the other tubes remained clear and colourless after standing for twelve hours. The test was repeated several times on corroded portions cut from the rods and tubes, distinct evidence of the presence of ammonia being obtained in every case.

(*b*) *Test for Nitrates.*—Water extracts of corroded fractures prepared in the same way were carefully poured on to the diphenylamine solution described above, but the blue ring which indicates the presence of nitrates was not obtained. Fractures were also allowed to stand in very dilute sulphuric acid solution; these extracts added to diphenylamine solution failed to give a blue ring.

After three days' treatment the upper cup had lost its ring, and after ten days this cup was found to be cracked. The water in the trap was tested with Nessler's solution, and a heavy precipitate was obtained indicating the presence of ammonia. In similar experiments in which town gas was burnt under the funnel in a bunsen burner, the water from the trap gave a slight precipitate with Nessler solution, indicating that small amounts of ammonia are given off by an ordinary bunsen flame.

Note on Ammonia in the Atmosphere.—The atmosphere fall of temperature contain an appreciable quantity of ammonia.

5. *Small Studs.*—An example of season-cracking under externally applied stresses was provided by small studs, made of a common quality of 60 : 40 brass. They had been subjected in use to variable tensile stresses and to the action of ammonium nitrate solution, which had corroded them. Their Brinell hardness ranged from 120 to 150. Microscopic examination showed that the cracks followed an intercrystalline path and were generally

Fig. 17.

Season-Cracks in Deformed 70 : 30 Brass, following an Intercrystalline Path. × 100.

Fig. 18.

Fire Cracks in 70 : 30 Brass. Produced by Rapid Local Heating of a Spun Cup. Intercrystalline. × 100.

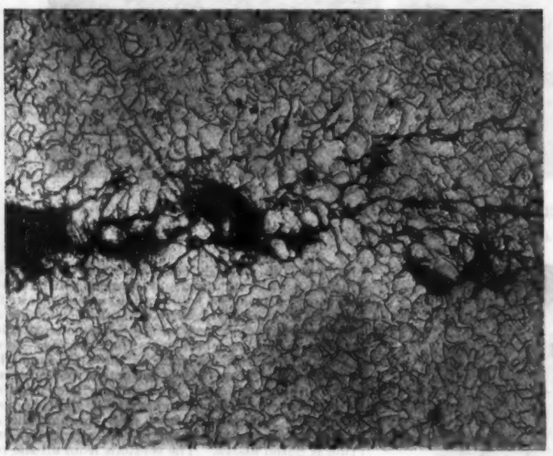


Fig. 19.

Season-Cracks in 60 : 40 Brass, following an Intercrystalline Path. Selective Corrosion of β and Corrosion of both α and β in the more Severely Corroded Areas. × 250.

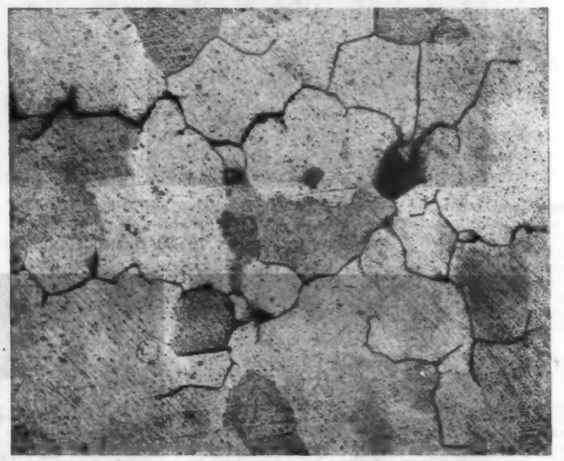


Fig. 20.

Season-Cracks in a β Brass. Intercrystalline. × 250.

Source of Ammonia.—The store in which the cracking of the rods and tubes had occurred was heated in the winter by slow combustion stoves burning waste sap-wood, the tops of which were often left open. Coal-burning locomotives also worked in the store occasionally. In the simple apparatus shown in Fig. 21 the products of combustion of wood were tested for ammonia and for their effect on stressed brass.

Two spun cups of 70 : 30 brass, identical with those described in the authors' previous paper, in which the outer layer is stressed in tension to a high degree, were placed in the closed space in the position shown in Fig. 21. In the earlier experiments the washing bottle between the funnel and closed space was not included, but it was found that a certain amount of tarry matter distilled over. The trap containing distilled water between the closed space, and the pump prevented water being sucked back into the closed space and also collected any soluble gases present in the fumes given off by the burning wood. Air was drawn through the apparatus by means of a pump. Small blocks cut from a piece of sap-wood oak taken from the fuel used for the stoves were supported on wire gauze and were kindled by means of a bunsen burner, which was removed when the wood was well alight. The fumes were drawn through for ten minutes four times each day, the cups being left in contact with the fumes overnight.

contains small and very variable but appreciable amounts of ammonia. Angus Smith found that 1,000 grms. of air contained—

London ...	...	0·05 grm. ammonia.
Glasgow ...	...	0·06 ,, ,,
Manchester	...	0·10 ,, ,,

Rain water contains appreciable amounts of ammonia, especially in large towns, and after rain the ammonia-content of the atmosphere is reduced. In a building in which ammonia is being generated, even if only in very small quantities, it is probable that the figures given above are far exceeded, and that deposits of moisture caused by

of the same type as the season-cracks found in internally stressed α β brass.

6. *Summary.*—The examination of a considerable number and variety of brass specimens in which season-cracks were found, and the comparative examination of specimens free from cracks, but identical in other respects, has shown in the first place that season-cracking occurs in brass objects differing very widely in form, composition, freedom from impurities, structure, hardness, and other physical properties. The features common to the season-cracked specimens are: 1. A state of initial stress, nearly always internal stress, *i.e.*: not caused by the application of external constraint; 2. A certain degree of strain-hardening caused by cold-work; 3. Chemical action on the surface of the brass, frequently resulting in corrosion; 4. The intercrystalline path of the cracks.

It is probable that strain-hardening is not a condition essential to the formation of season-cracks, but that the internal stresses primarily responsible for the cracking are nearly always the result of cold-work operations which have hardened the brass. For a given composition of brass the range of hardness of specimens in which season-cracks have formed and extended is very wide. Spinning and drawing are indicated as cold-work operations especially liable to induce such stresses. In some instances the evidence of chemical action is small, as in

cases in which cracks have not only spread but have initially formed below a continuous layer of lacquer. Reasons will be given later for holding the view that chemical action of certain kinds on the surface of the brass commonly, if not always, precedes season-cracking, and that continuous protective coatings fail to prevent such action in some circumstances. A continuous coating of nickel appears to be a completely effective protection; the removal of the nickel coating from a specimen of internally stressed brass was followed by the development of season-cracks in the areas from which this protection had been removed. No evidence has been obtained indicating that any kind of surface injury other than that caused by chemical action will induce the formation of season-cracks in internally stressed brass. In one group of failures the action of ammonia or ammonium salts was clearly indicated as the agency which rendered the internal stresses active in producing cracks, and strong evidence of the action of ammonia was found in another large group of failures, the material (rods and tubes) in this case being of a different character. Reasons have been given for suspecting the action of ammonia or ammonium salts in many cases in which season-cracking may occur. In each of the numerous cases in which such tests have been applied to season-cracked brass, sectioning or machining tests have resulted in change of form revealing internal stress, and cracking has occurred in the mercurous nitrate test.

THE EFFECT OF CORROSIVE AND OTHER SUBSTANCES ON STRESSED BRASS.

1. *The Use of Small Spun Cups as Test-Specimens.*—The effect of certain substances in promoting the season-cracking of stressed brass has been indicated in the preceding section. Numerous experiments have been carried out to ascertain what classes of substances are capable of acting in this way as "accelerating agents" and what is the nature of their action. For this work large numbers of brass specimens or test-pieces, in a state of internal stress and identical in all respects, were required. The test-pieces should be reproducible in any quantity, and this requirement necessitated a standardized and fully defined method of preparation. The high stresses found in all the unannealed spun vessels examined, as indicated in the preceding section, suggested a similar method of preparation. Small spun cups of the kind described in the authors' earlier paper were found to be entirely satisfactory. A large supply of pure 70 : 30 brass strip, rolled from one ingot, was obtained. The greater part of this was fully annealed to a uniform hardness. From this strip discs of uniform dimensions were cut, and by using the same tools, formers and sequence of operations, identical and highly stressed cups were produced. Uniformity of properties has frequently been checked by Brinell hardness tests and by carefully milling strips from the cups and measuring the amount of springing out. The test most frequently applied as a check on the uniformity of the state of stress has been immersion in mercurous nitrate solution. At first some irregularity in behaviour under this test was observed, in such points as the time required to develop cracks, but this was soon found to be due to differences in the mode of application of the test, not considered at first to be of importance. As will be seen later, immersion in mercurous nitrate solution should be preceded by pickling for a definite time in nitric acid of fixed strength.

A great many tests, applied at intervals during some years, have shown that with uniform conditions of applying the mercurous nitrate test the spun cups were remarkably uniform in their behaviour, little variation occurring in the time required to develop cracks or in the form, position, or width of the cracks.

Details of the composition and dimensions of the brass sheet and of the form, dimensions, and hardness of the cups are given in the authors' earlier paper. All brass spun cups used in the work described in the present paper were made from the same lot of strip; except where it is otherwise stated, the strip had been fully annealed to a uniform Brinell hardness of 58 to 60, and no annealing was applied during or after spinning.

Before proceeding to a description of the trials of the effect of corrosive and other substances, it may be desirable to record certain experiments throwing further light on the properties and behaviour of the sound cups used as test-specimens.

Mercurous Nitrate Test applied to Spun Cups.—It was found that if preliminary pickling was omitted or imperfectly carried out, the time required to develop cracks in mercurous nitrate solution varied greatly. This was particularly noticeable in the weak solutions, *e.g.*, one containing 0·1 per cent. mercurous nitrate and 0·1 per cent. nitric acid (1·42 sp. gr.), the times in which cracks appeared after treatment in this solution varying from five minutes to twenty-four hours. A standardized method of pickling was therefore laid down. The specimen was pickled for thirty seconds in a bath containing 40 volumes of nitric acid (1·42 sp. gr.) and 60 volumes of water, thoroughly washed in water and then immersed in the mercurous nitrate bath. After this treatment the spun cups invariably cracked in from two to three minutes in 0·1 per cent. mercurous nitrate solution and in from thirty to forty-five seconds in the 1 per cent. solution. Quick and thorough washing after the immersion in nitric acid is necessary to prevent the formation of an oxidized film, which seriously retards the deposition of mercury. Wherever pickling is mentioned in this paper this standardized method is implied unless it is otherwise stated. The first appearance of cracks is indicated by the disappearance of mercury from the surface of the brass surrounding the crack, revealing the yellow colour of the brass. This effect appears to be due to the mercury running into the crack, but when the crack has fully developed, the mercury ceases to flow from the surface of the surroundiug brass and a good deposit of mercury is again obtained by interaction of the brass with the solution.

The important effect of the preliminary pickling was further shown by the following experiments. Two cups were pickled as described and two were polished. They were then immersed in 1 per cent. mercurous nitrate solution containing 1 per cent. of nitric acid. The pickled cups cracked more rapidly than the polished cups, although all had apparently taken an equally good coating of mercury. A number of cups were weighed after cleaning with benzene, a similar number were weighed after polishing with 000 polishing paper, and a further set were weighed after pickling. These were all treated in the 0·1 per cent. mercurous nitrate solution containing 0·1 per cent. nitric acid for 5 minutes, and were weighed after removal from the solution and careful drying. The gain in weight of the cups varied from 0·0024 gramme to 0·0039 gramme, the average gain being the same in each set. The pickled cups were found to be cracked on removal from the solution, while none of the others were cracked. The polished and benzene-cleaned cups cracked in from 45 minutes to 24 hours, with the exception of two polished and one benzene-cleaned cup, which had not cracked two days after the mercurous nitrate test. These were re-treated for 5 minutes in a 0·1 per cent. solution of mercurous nitrate and were found to be cracked on removal from the solution.

To test the suggestion that the stresses might have been reduced by polishing, two cups, polished as described above, and two unpolished cups, were then pickled by the standardised method. After weighing, the cups were immersed in the 0·1 per cent. solution of mercurous nitrate for 5 minutes. The cups cracked in the same time, and all were badly cracked on removal from the solution. The cups were again weighed; the gain in weight was uniform and about the same as in the preceding experiment.

The cups used in these comparative trials were stored in a room at ordinary temperatures after the mercurous nitrate test, and it was observed that the mercury disappeared from the surface of the pickled cups at an almost uniform rate, a little more rapidly on the dome than in the interior of the cup; the mercury disappeared in about 24 hours. In the case of the polished cups the mercury disappeared very quickly from any part over which the roller used in spinning had passed, the time taken being on the average about 2 hours: the rate of disappearance of the mercury from the interior surface was much the same in the polished as in the pickled cups.

Action of Ammonia on Spun Cups.—Two benzene-cleaned, two polished, and two pickled cups were placed in a closed space over 0·880 ammonia and were visually examined at short intervals. Since it had been noticed that cups placed in or over ammonia lost their clear bell-like ring before cracks were visible, the cups were tested at intervals by gentle tapping. At the end of 30 minutes the pickled cups had lost their ring, while in the polished and benzene-cleaned cups the ring had not diminished. No further change occurred in 2 hours except by progressive tarnishing, most marked in the polished and benzene-cleaned cups. After 4 hours the pickled cups had cracked badly, while no cracks were visible in the polished and benzene-cleaned cups, although all had lost the clear ring. No further change was observed after 8 hours, but after 24 hours' treatment all cups were badly cracked and dark green spots of liquid were found on them. The cracks were similar in form to those developed in mercurous nitrate solution, although the cracks parallel to the flange developed by ammonia treatment were rather more pronounced. An examination of fractures showed that they were more corroded near the surfaces originally in tension, suggesting the cracks had started at the surface which was in tension.

Cups Spun from Hard-rolled 70 : 30 Brass.—Experiments were carried out in order to ascertain the maximum hardness of 70 : 30 brass sheet 0·035 in. thick which could be spun into cups of the standard form and dimensions. As a result of numerous trials it was found that brass with a Brinell hardness of from 120 to 130 was the hardest which could be spun into cups without cracking badly. Even brass of this hardness gave a small percentage of failures, but by careful rolling from the top of the dome towards the flange the metal was gradually forced down on the former. Owing to the much greater pressure required, the metal spread rather more than the fully annealed brass, and hence the cups spun from hard brass were slightly thinner and the flanges a little wider.

Diametral strips, ¼ in. wide, were cut from two of the cups. The overall diameters were measured before and after cutting. The increase in diameter was 0·2 and 0·22.

Brinell hardness tests were made with a ball of 1 mm. diameter and a load of 10 kg. on the outside surface of the cups. They gave an average result of about 146. The variations from the average Brinell hardness figures at each position tested were very small.

Mercurous Nitrate Tests applied to Cups Spun from Hard-rolled Sheet.—Cups spun from sheet with a Brinell hardness of 126 were pickled in 50 per cent. nitric acid solution for 30 seconds, and after thorough washing were immersed for 5 minutes in a 1 per cent. solution of mercurous nitrate containing 1 per cent. of nitric acid (1·42 specific gravity), 500 c.c. of solution being used for each cup. The first cracks appeared in about the same time as in the cups spun from soft brass, but instead of developing near the flange they appeared between 1·25 in. and 1·5 in. from the dome, the next cracks forming in the top of the dome, while cracks developed near and across the flange later. The first series of cracks were parallel to the direction of rolling of the strip from which the cups were made, although cracks developed in other directions in later stages of the cracking.

Action of Ammonia on the Harder Spun Cups.—Two cups spun from hard-rolled strip B were pickled in 50 per cent. nitric acid solution until the crystalline structure could be clearly distinguished, while two cups identical in properties were thoroughly cleaned with benzene. These were placed in a closed space over 0·880 ammonia and all rapidly tarnished. Two hours after the commencement of the trial the pickled cups had lost their ring, but visible cracks had not developed until 8 hours after the commencement of the trial. The polished cups began to lose their ring 6 hours after the commencement of the trial, visible cracks had not appeared in 12 hours, but both cups were badly cracked in 24 hours. The pickled and polished cups were very similar as regards form and distribution of cracks after the 24 hours' treatment. In all cases the cracks started near the top of the dome and developed in branching systems towards the flange. From the comparative trials made with spun cups (1) merely cleaned, (2) polished, (3) pickled, it would appear that the cleaned or polished cups have a surface layer which is more or less protective against the action of substances which accelerate season-cracking, and that this layer is removed by a suitable pickling with nitric acid. Experiments described in later sections throw more light on the nature and mode of action of this protective layer.

2. *Trials of Corrosive and other Substances.*—The paper gave particulars of trials with three series of specimens in various solutions, and details concerning their behaviour in these.

Dry Ammonia Gas.—A slow stream of ammonia gas from a cylinder was passed through drying towers containing soda lime, and over dry cups, and was then absorbed in concentrated sulphuric acid. The cups tarnished slowly, and no diminution in "ring" (the first indication of incipient cracking) was observed until after 30 hours. Visible cracks appeared after 48 hours. These times were very much longer than the 30 minutes and 4 hours required to produce the same effects in a mixture of ammonia gas and damp air. It may be doubted whether all trace of water vapour had been removed from the ammonia.

Nitric Acid.—Six cups were pickled in a 50 per cent. solution of nitric acid (1·42 specific gravity). During pickling the cups were examined at frequent intervals, but no cracks had appeared, even when the cups were extremely thin. When the cups were pickled uniformly no distortion occurred, but in one which was pickled until the dome separated from the flange, the flange portion bent, and when flattened and released sprang back to the bent form. After pickling, five shells were immersed in a 0·1 per cent. mercurous nitrate solution for 5 minutes and all were found to be cracked on removal from the solution.

3. *Summary.*—It was known that certain chemical substances accelerated the cracking of stressed brass. Small cups spun from brass sheet proved to be very suitable as test specimens in determining whether a particular substance would induce cracks in stressed brass. Cups were spun from annealed and from medium hard-rolled brass sheet; the further increase in hardness caused by spinning was measured. Cups of each kind were remarkably regular in their properties and behaviour when the materials and processes of manufacture were standardised and after a very thin layer had been removed from the surface by a light, pickling, and the amount and distribution of the internal stress appeared to be the same in all cups of one kind. Of a number of substances tested, including strongly corroding reagents such as nitric acid, hydrochloric acid, nitrogen peroxide, and sulphur trioxide in damp air, none produced cracks except ammonia, ammonium nitrate and mercury, applied as solutions of mercury salts, although the trials were prolonged and severe corrosion and pitting occurred, sometimes eating holes in the specimen. Mercurous nitrate tests on corroded specimens, free from cracks at the conclusion of the prolonged trials, demonstrated the continued presence of severe internal stresses. The inclusion of unstressed cups and other specimens in the trials showed that season-cracking occurred only when the brass was in a state of internal stress.

The conclusion is reached that season-cracking is not induced in stressed brass by the mechanical weakening of the stressed surface consequent on the irregular removal of metal by corrosion, but is induced by the specific action of certain chemical substances, of which ammonia with its compounds and mercury are the only examples among the substances mentioned in this paper. The observation that of a number of highly-stressed spun cups kept in atmospheres of ordinary purity for four years not one has cracked, suggests that season-cracking of stressed brass is never "spontaneous," but can only be induced by chemical action of the kind indicated.

The action of a damp mixture of ammonia gas and air and of strong ammonia solutions is very rapid in inducing cracks in stressed brass; cracks are formed at a very early stage in the corrosion, and in some cases no corrosion is apparent. The action of dry ammonia gas is much slower.

(To be continued.)

THE SHIPPING EXHIBITION AT OLYMPIA.—The Shipping, Engineering and Machinery Exhibition will be held at Olympia, from the 7th to the 28th of September, and it is expected that an unusually large and representative collection of machinery will be on view. All the leading Institutions devoted to shipbuilding and engineering generally are associated with the Exhibition, a special feature of which will be the display of machinery in motion. Demonstrations of life-saving at sea, the work of divers, and wireless communication will be given, and many other attractions appealing both to engineers and laymen. The Exhibition offices are at 36, Whitefriars-street, London, E.C.4.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACTS OF 1907 AND 1919.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the communicators are given in italics.

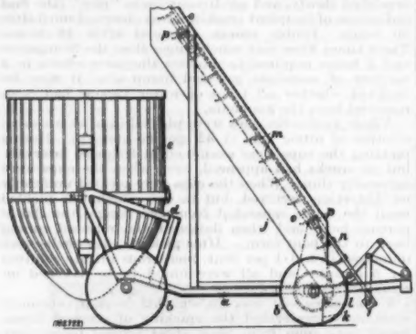
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 1s.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

AGRICULTURAL APPLIANCES.

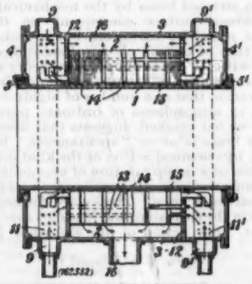
162,722. G. P. Makepeace, Bardon Mill, and W. Henderson, Bardon Mill. Hay Cocking Machines. (3 *Figs.*) September 30, 1920.—The improvements relate to hay-cocking machines comprising a truck *a* which is mounted upon wheels *b*, and is provided at its rear end with a pair of frames *d* to support a mould *e*. The front end of the truck serves as a support for a conveyor, which consists of a trough *j*, the upper end of which is located above the open end of the mould *e*, whilst the lower end is disposed in front of the front pair of travelling wheels and a distance above the ground, the intervening space being filled by a barrier consisting of a plurality of vertically-arranged tines *k*, so mounted upon a shaft *l* as to give rearwardly upon striking an obstruction. The lower ends of the tines are always



normally in contact with the surface of the ground from which they collect the hay to be cocked. The hay accumulates in front of the tines, from whence it is removed by the forks *m*, carried by a series of bars *n*, that extend longitudinally of the trough *j* within the interior of the same and are individually supported at each end upon cranks *o*. The cranks are connected together by means of sprocket wheels *p* and endless chains which, in turn, are driven from the front travelling wheels. The movement thus produced causes the bars *n* to dip alternately towards the floor of the trough *j*, and also to move upwards thereover so as to urge continually the hay up the floor of the trough to be finally ejected over the top in a continuous flow. (*Sealed.*)

ELECTRIC APPARATUS.

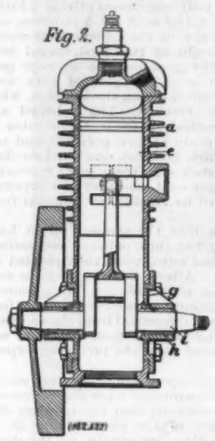
162,552. Siemens Brothers Dynamo Works, Limited, London, and P. H. H. Jantzen, London. Dynamo Electric Machines. (4 *Figs.*) May 20, 1920.—For cooling the stator and rotor of a dynamo electric machine, the stator and rotor are separated by a partition 1 of non-magnetic and high-resistance material, the stator winding overhangs being immersed in oil which flows through axially disposed passages provided in the stator core 2, and the rotor being cooled by an independent flow of insulating fluid circulating, also, through axially-disposed passages in the core, the flow of oil through the axially-disposed passages in the stator core being supplemented or replaced by a flow in directions transverse to the axis. 3 is the casing enclosing the stator. End shields 4 and 4¹ are secured at their outer perimeters to flanges on the casing 3. Leakage of oil at the inner perimeter of the end shields 4, 4¹ is prevented by packing which is

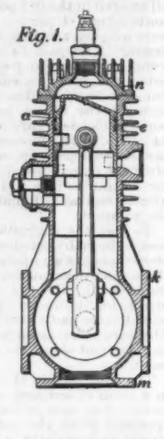


pressed between the inclined surfaces of the shields 4, 4¹ and of the partition 1 by rings 5, 5¹ tightened by means of bolts. An annular chamber 9, 9¹ is provided near each end of the casing 3 into which oil is introduced through pipes. Perforated plates 11, 11¹ separate the passages 9, 9¹ from the winding compartments. The holes in the plates 11, 11¹ are graduated in size, so as to distribute the flow of oil uniformly over the ends of the stator core. The oil enters by the pipes and flows through the perforated plates 11, 11¹ and perforated core end plates 12 enclosing the laminations of the stator core 2. Holes in the plates 12 correspond with axial passages 13 in the core which communicate with transverse passages 14 between the laminations. A narrow passage 15 between the inner ends of the core and the partition 1 receives oil from the chambers 9, 9¹ and allows it to flow in the transverse ducts 14 in contact with the inner ends of the laminations. There is, consequently, a flow of oil in an axial direction through the core and in a transverse direction between the laminations. After traversing the core the oil emerges by the pipe 16 and can be cooled externally before it is caused to re-enter the pipes. In order to obtain a more uniform distribution of the oil in the stator core, tubes are inserted to convey the axially-flowing oil past certain of the transverse spaces provided between the laminations. (*Sealed.*)

GAS ENGINES, PRODUCERS, HOLDERS, &c.

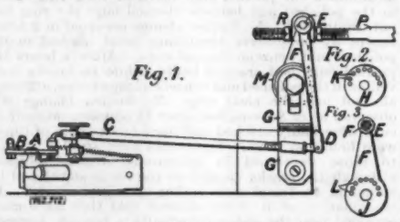
162,527. T. H. Parker, London. Internal-Combustion Engines. (3 *Figs.*) April 15, 1920.—The novel feature consists in forming the cylinder *a* and crank-case in one piece, and in providing in the crank-case side openings which are closed by plates *g*, carrying bearings *h*, for the shaft *i* of the engine. The crank-case has flanges *k*, *m*, by which the engine can be fixed.





The bottom of the crank-case has an opening closed by a plate, through which access can be had to the crank-case. This opening is adjacent to the fixing flange *m*. The plates *g* for the crank-case bearing are exchangeable to suit different bearings or shafts. The top end of the cylinder is closed by a cover *n*. (*Sealed.*)

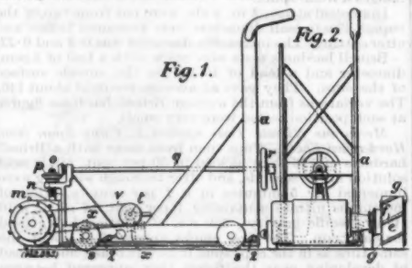
162,712. J. B. Brown, Edinburgh. Internal-Combustion Engines. (5 *Figs.*) December 19, 1919.—In internal-combustion engines used in motor vehicles, in which a foot pedal P is employed for opening and closing the throttle valve of the engine, the throttle valve spindle A is fixed to a lever B, which, through a connecting rod C, is connected to one end of a lever D, the other end of lever D being fixed on a spindle E which is supported in a bearing at the upper end of an adjustable frame F carried in a slotted standard G. The frame F is adjusted by two discs H, J, the discs being provided on their adjacent faces, near their peripheries, with a number of recesses K, L. Interposed between



the two discs H, J is a third disc M carrying a ball which extends on each side of the disc and projects into one of the recesses K, L in the discs H, J, so that when the discs are clamped together, the frame F, which forms a part of the disc J, is held to the frame G in the desired position. To prevent the bolt of the nut turning in the slotted standard G, it is flattened or squared on two sides. The foot-pedal P is screwed and carried in a split ring R mounted on the spindle E, so that it can not only be adjusted vertically, but also adjusted laterally and longitudinally. The foot-pedal lever P, after being adjusted, is held in position by two nuts. (*Accepted May* 19, 1921.)

MACHINE AND OTHER TOOLS, SHAFTING, &c.

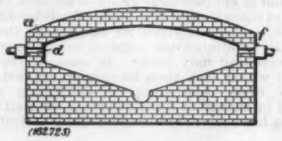
162,585. Swan, Hunter and Wigham Richardson, Limited, Wallsend-on-Tyne, and J. Holdcroft, Cullercoats. Wood Planing Machine. (7 *Figs.*) July 28, 1920.—The novel feature in a machine tool of the type used for planing wood floors and ship's decks, and comprising a frame *a*, a rotary cutter *f* mounted on the frame, a motor for driving the cutter,



and means for raising and lowering the cutter consists in disposing the rotary cutter *f* at the side of the machine and projecting therefrom. For some classes of work, the rotary cutters are narrow and staggered, and a belt or pulley drive is included in the transmission of power to the travelling wheels. The cutters *f* are mounted on a drum *e* which is placed either on the right or left-hand of the motor on the extreme outside of the frame *a*. The cutters are disposed obliquely and dovetailed with the drum *e* and are held in place by keeping rings *g* secured by screws to the sides of the drum *e*. The drum *e* is mounted on a bracket *m* provided with guides to work in corresponding grooves formed in the head plate *n* of the frame *a*. The bracket *m* is raised and lowered by means of a screwed stem *o*, bevel wheels *p*, *p*, shaft *q* and operating wheel *r*. The frame is mounted on four wheels *s*, *s*, and is driven through counter shaft *t*, belt *v* and worm gears *x*, *x*. Scrapers 2, 2 are fitted to scrape the wheels *s*, *s* continuously when the tool is in use. (*Accepted May* 11, 1921.)

MINING, METALLURGY AND METAL WORKING.

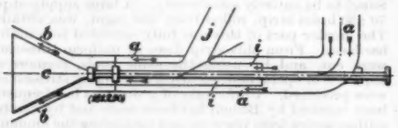
162,725. D. Wright, Ulverston. Smelting Iron Ore. (6 *Figs.*) November 2, 1920.—The process for the production of iron by the smelting of iron ore, according to this invention, consists in blowing, by means of rotary atomising apparatus housed in the passage *f* into and burning in a furnace *a* and by an oxidising flame, atomised liquid fuel, until a desired temperature (about 1,500 deg. C.) is attained; diminishing the supply of air so that incomplete combustion of the liquid fuel results and the furnace contains a continuously renewed superheated atmosphere of carbon monoxide gas; blowing through the



carbon monoxide atmosphere and into the furnace iron ore in the form of an atomised or flour-like spray, or sprays, so that instantaneous chemical reaction takes place; and then, after the temperature of the furnace has been reduced somewhat (to about 1,150 deg. C.), due to absorption of heat in the process of reduction, interrupting the admission of atomised ore to the furnace and increasing the supply of air, so that the flame reassumes an oxidising character, until the temperature of the furnace has been elevated again. The furnace floor slopes downwardly towards the middle, at which a channel *c* is formed to receive the molten metal. (*Accepted May* 19, 1921.)

STEAM ENGINES, BOILERS, EVAPORATORS, &c.

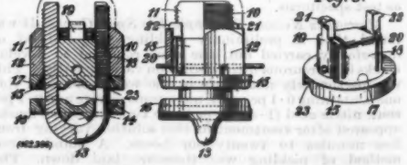
161,250. D. Wright, Ulverston. Furnaces. (6 *Figs.*) January 2, 1920.—Apparatus for spreading and discharging granular or pulverized fuel by air under pressure comprises a conduit *a* for air under pressure, the discharge mouth *b* whereof is of outwardly-tapering or conical shape, a body *c* concentrically disposed in the discharge mouth so that fuel passing outwards is, by deflection, spread and discharged, a pipe *i* disposed within



the conduit *a* and having a branch *j* through which the fue falls by gravity so that it is forced by air under pressure passing through the pipe *i* towards the discharge mouth *b*. The branch *j* is inclined rearwardly from the discharge mouth *b*. The deflector body *c* may be adjustable in the discharge mouth *b*, so that the space between them may be regulated, as desired. (*Sealed.*)

MISCELLANEOUS.

162,366. G. V. Twiss, London. Clamping Devices. (5 *Figs.*) January 24, 1920.—The invention provides an improved method of mounting a washer on a screw-threaded stem carrying a nut. The clamping device has a U-shaped bolt having the two limbs 10, 11, of segmental form with a screw-thread formed on the outer exposed surface. A nut 12 encircles the two limbs 10, 11, being screwed on to the thread. The lower ends of the two limbs are joined together by a head 13, and the elements to be clamped are inserted in the spaces 14 between the limbs. The element is secured by screwing down the nut 12, but a washer 15 is interposed between the nut and the head 13, so that it grips one element and a supplementary washer 16 is also used. The washer 15 comprises a disc formed with segmental perforations 17, by which it is threaded on to the two limbs 10, 11 of the U-shaped bolt. A central block 18 occupies the space between the two openings 17 and serves as a support for the limbs 10, 11 against movement towards one another under the pressure exerted by the nut 12 on the thread. At the ends of this block there are formed two projections 19, 20, which are so situated that they can lie within the threaded bore



of the nut 12, and they are separated from the block 18 by saw cuts. They are formed with outwardly-directed lateral extensions 21, 22, which are situated at such a height above the upper face of the disc 15 that the nut 12 can lie between the upper face of the disc 15 and the lower faces of the projections, and the projections are of such radial length that they extend over the upper surface of the nut. The projections 19, 20 are sprung together to enable the extensions 21, 22 to pass through the threaded bore of the nut 12. When thus passed through, the projections 19, 20, are allowed to spring out to their original position so that the nut is locked to the washer but is capable of rotation relatively thereto. The two together are applied to the bolt, by passing the limbs 10, 11 of the bolt through the segmental openings 17 until the threaded parts of the limbs engage the threaded bore of the nut. The nut can then be screwed down the limbs of the bolt, and in so doing the washer is prevented from rotation owing to the engagement of the block 18 between the limbs of the U-shaped bolt. A groove 23 is formed on the underside of the washer 15 when the clamping device is used for securing a wire or rod, which is threaded through the space 14. (*Sealed.*)